AD-A069 473 BOEING AEROSPACE CO SEATTLE WASH F/G 9/5

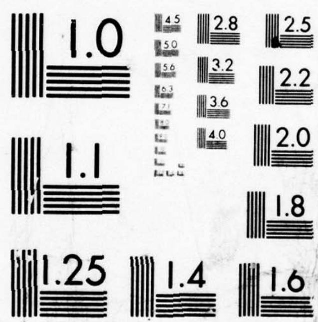
HIGH VOLTAGE SPECIFICATIONS AND TESTS (AIRBORNE EQUIPMENT). (U)

APR 79 W G DUNBAR, W P KOENIG F33615-77-C-2054

UNCLASSIFIED AFAPL-TR-79-2024 NL

1 OF 6

AD
A069473


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

AFAPL-TR-79-2024

LEVEL II

HIGH VOLTAGE SPECIFICATIONS AND TESTS (AIRBORNE EQUIPMENT)

AUTHOR: W.G. DUNBAR

BOEING AEROSPACE COMPANY
P.O. BOX 3999
SEATTLE, WASHINGTON 98124

APRIL 1979

FINAL REPORT 17 AUGUST 1977 - 30 SEPTEMBER 1978

Approved for public release; distribution unlimited.

AIR FORCE AERO PROPULSION LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Hugh L. Southall

HUGH L. SOUTHALL, Capt., USAF
Project Engineer

Richard L Verga

RICHARD L. VERGA
TAM, High Power Branch
Aerospace Power Division

FOR THE COMMANDER

James D. Reams

JAMES D. REAMS
Chief, Aerospace Power Division

"If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization please notify AFAPL/POD-1 *,W-PAFB, OH 45433 to help us maintain a current mailing list".*

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(19) **REPORT DOCUMENTATION PAGE**

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER (18) AFAPL-TR-79-2024	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) HIGH VOLTAGE SPECIFICATIONS AND TESTS (AIRBORNE EQUIPMENT).		5. TYPE OF REPORT & PERIOD COVERED (9) Final Report, 17 Aug 1977 — 30 Sept 1978
		6. PERFORMING ORG. REPORT NUMBER ~~1~~
7. AUTHOR(s) (10) W. G. Dunbar, W. P. Koenig		8. CONTRACT OR GRANT NUMBER(s) (15) F33615-77-C-2054
9. PERFORMING ORGANIZATION NAME AND ADDRESS Boeing Aerospace Company P. O. Box 3999 Seattle, Washington 98124		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (16) 3145-(17) 32-38
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Aero-Propulsion Laboratory AFAPL/POD-1 Wright-Patterson AFB, Ohio 45433		12. REPORT DATE (11) April 1979
		13. NUMBER OF PAGES 539
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 550p.		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Airborne Equipment	Converter	Partial Discharges
Cables	High Power	Partial Discharge Test Set
Cable Assemblies	High Voltage	
Capacitors	Power Characteristics	
Connectors	Transformers	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Design engineers rely upon system and component standards and specifications as guides for developing electrical equipment. Specifications and standards are available for most low voltage and commercial high voltage equipment, but not for high voltage/high power airborne equipment with ratings exceeding 20KV and 20KW. The test and specification criteria (Engineering Criteria Documents) referred to in this paper pertain to high voltage/high power airborne equipment.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

059610

1B

FOREWORD

This final technical report covers work performed under Contract F33615-77-C-2054 with the U. S. Air Force, Air Force Systems Command, Air Force Aero Propulsion Laboratory, Wright-Patterson Air Force Base, Ohio. The work was performed in the Electrical Power Organization in the Boeing Aerospace Company. Work described herein covers the period from 17 August 1977 to 30 September 1978.

The program is under the direction of Captain Hugh L. Southall of the USAF Aero Propulsion Laboratory.

The Boeing program manager is S. W. Silverman, and the report was authored by the principal contributors to the program.

W. G. Dunbar

W. P. Koenig

The U. S. Air Force (High Power Branch) Aeropropulsion Laboratory, Power Division at the Wright-Patterson AFB is conducting studies and funding programs in support of high power/high voltage aircraft systems and equipment. Included in this document are eight specification criteria documents for high power/high voltage equipment and systems. In addition, the development of a partial discharge test set is described.

These specification criteria documents will be most useful if they command widespread acceptance. Such acceptance is most probable if the documents have been made responsive to the needs of the technical community. It is therefore very important that all comments, both positive and negative, be forwarded to the U. S. Air Force Aero Propulsion Laboratory (AFAPL/POD-1 Wright-Patterson AFB, OH 45433) for consideration in future versions of the criteria documents.

SUMMARY

This report contains eight high power/high voltage criteria documents for lightweight, low volume, high efficiency equipment and systems. These systems and equipment must have high mean time between failures and high reliability so they can be used in manned aircraft. Also included in this document is the discussion of the development of a partial discharge test set used to evaluate parts, modules, and assemblies for the high power/high voltage systems.

The eight high power/high voltage specification criteria documents for high power/high voltage electrical equipment and systems included in this report are listed in Table 1.

TABLE 1. HIGH VOLTAGE SPECIFICATION CRITERIA DOCUMENTS

Document	Appendix	Page
Cables	A	103
Cable Assemblies	B	143
Capacitors	C	175
Connectors	D	247
Converters	E	275
Power Characteristics	F	337
Power Sources	G	365
Transformers and Inductors	H	453
Interim Report	I	537
Distribution List		

An interim report for the documents of Appendices A through F and H was transmitted to several government and industrial agencies for comment and critique in June 1978. A list of these agencies is included in Appendix I. The screened and edited comments are included in this updated final report.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I

INTRODUCTION

1.1 Objectives. The objectives of the contract are to develop engineering criteria documents and test procedures which shall assure that future high power/high voltage airborne equipment shall meet mission requirements with adequate life, reliability, safety and electromagnetic compatibility.

1.2 Scope. Government and industrial specifications and standards applicable to high power/high voltage equipment and components are included in the documentation. Modifications and revisions to those specifications and standards are referenced and the additional new material justified.

High voltage tests used for electrical insulation evaluation include volume resistivity, dielectric withstanding voltage, partial discharges, and impulse voltage. The first two tests and test equipment to perform those tests are described in Military Specifications and Standards. The partial discharge test, though an old test, is not as well defined. A partial discharge test set with calibration and test procedures is described herein. This test equipment can be used to evaluate insulation and insulation systems, models, components and assemblies for cracks and voids, within the insulation, the major cause of most insulation failures.

1.3 Discussion. Electrical insulation plays a crucial role in compact high voltage equipment. So far there is no insulation that has ideal electrical, thermal, and structural properties, hence the engineer must recognize that each application has a set of insulation designs that can satisfy the electrical performance, environmental and structural constants. For example, capacitors require materials with high dielectric constants, whereas insulators or feedthroughs require good structural properties with low dielectric constants. Insulators for solid state devices require high heat transfer rates which are usually not associated

with low electrical conductivity. Thus, the designer is always evaluating compromises when selecting electrical insulation for compact, high voltage equipment.

The detailed design of system components and circuits is not described for the high power/high voltage equipment and systems. However, pertinent design-oriented papers are referenced for those who are interested [1,2,3]. This document deals with the development of requirements set forth in specifications which are referred to as Engineering Criteria Documents for high voltage/high power components and circuits and the planning of testing that ensures that the requirements are met. The Engineering Criteria Documents should form the foundation for future military specifications and standards for high voltage/high power airborne power supply components. Good criteria documents for equipment design and packaging must:

- clearly define electrical, mechanical and environmental parameters for the component or system.
- allow the designer to select materials with which he is familiar, yet must be rigorous enough to eliminate marginal materials through evaluation testing.
- include tests to determine that electrical, mechanical, chemical, and environmental parameters are within the stress limits of the parts and equipment.
- be realistic; i.e., parameters should include storage time, operating time, and environmental effects.

Partial discharge test specifications call out a test but seldom specify the test instrument sensitivity or a pass/fail criterion for partial discharges within an insulation. When lightweight, high density packaging is required for a specific design it becomes necessary to electrically stress the insulation much greater than normally encountered in terrestrial commercial applications. Therefore, a need for high voltage partial discharge test equipment is necessary to test, evaluate, and determine partial discharge parameters for these new applications. A partial discharge test set was assembled and tested for use in this program.

SECTION II

BACKGROUND

The U.S. Air Force has future needs for airborne power supplies which supply megawatts of power at tens of kilovolts which are defined as high power/high voltage systems. A generalized power supply is shown in Figure 1. The power source indicated in the figure is a turboalternator; however, by replacing the turboalternator with an MHD (magnetohydrodynamic) electrical generator, an MHD power supply results. Of course, the primary emphases on any airborne power system are minimum weight and volume, which imply compact systems with high density packaging.

Occasionally, a specification does not have electrical, mechanical, and environmental requirements and tests for high voltage and/or high power applications. Then deviations, deletions, and/or additional paragraphs must be included. For example, the tests in the military specification for transformers, MIL-T-27, are insufficient to ferret out pinholes and voids in the electrical insulation of high voltage transformers and inductors. A detailed partial discharge (corona) test is required to detect insulation faults between windings or between a winding and the frame or core.

Described below are a few of the inadequacies existing between shipboard and commercial requirements, specifications, and standards and those required for airborne systems. Foremost among the requirements are environment and life. Environmental changes include altitude, vibration, operation at nearly zero gravity (during quick descent), and wide temperature variations. Equipment life for an airborne system must include long storage periods, multiple starts and stops, and continuous operation in the airplane environment. This implies that the mechanical and environmental conditions for high voltage/high power equipment and systems are similar to low voltage/low power equipment and systems; however, the electrical conditions differ. Five significant electrical test additions include:

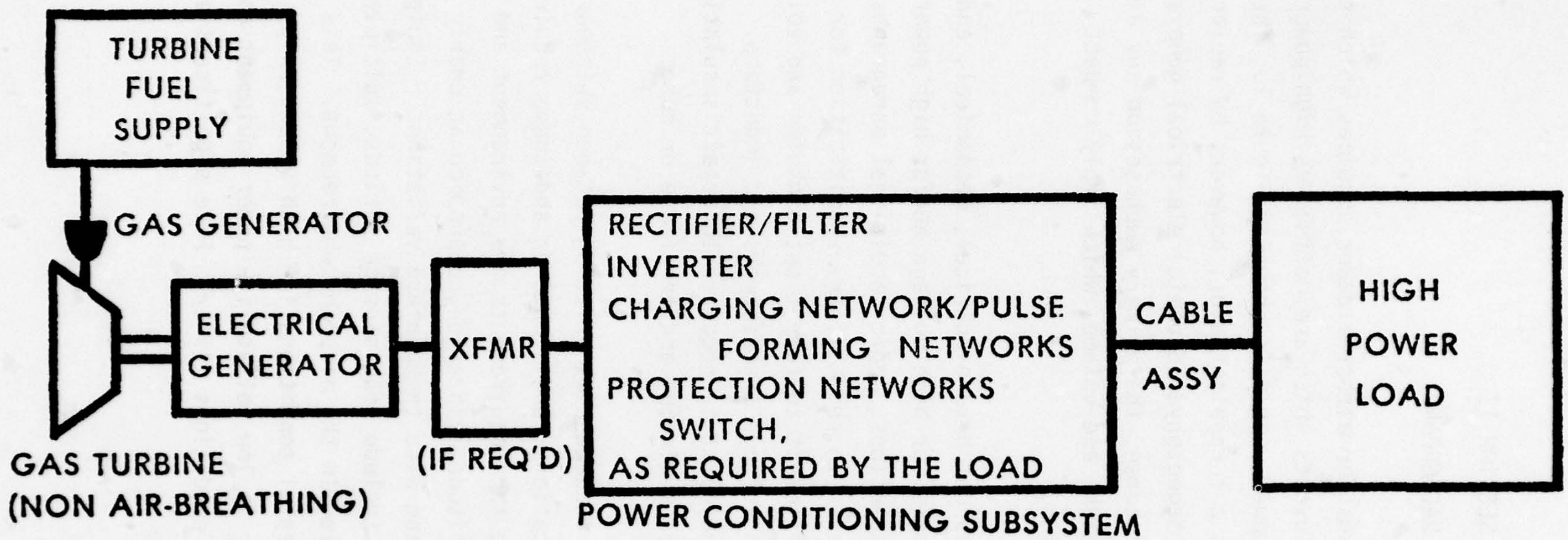


FIGURE 1. HIGH VOLTAGE/HIGH POWER AIRBORNE SYSTEM

- more stringent partial discharge test criteria
- modified dielectric withstanding voltage (DWV) tests; also called high-potential tests
- impulse tests to evaluate flashover characteristics
- ozone test criteria to determine ozone generation
- electromagnetic compatibility tests for components as well as the system

In addition, the power source may be cryogenically cooled. This will require a cooling criteria section for the power source criteria document. Finally, safety must be considered for all components and equipment. This will include special grounding or short circuiting terminating devices during shipping and storage.

SECTION III

ENGINEERING CRITERIA DOCUMENTS

The eight engineering criteria documents prepared and added as appendices to this report are shown in Table 2.

TABLE 2. ENGINEERING CRITERIA DOCUMENTS

Document	Appendix
Cables	A
Cable Assemblies	B
Cappacitors	C
Connectors	D
Converters	E
Power Characteristics	F
Power Sources	G
Transformers And Inductors	H

3.1 Literature Survey. A literature survey of government and industrial standards and specifications resulted in the accumulation of 3035 articles for the eight selected items. The scope of each article was scanned and a selected number of pertinent articles used for the final documentation as described in the subparagraphs below for each criteria document.

3.1.1 Cables. During the preparation of the high voltage cable criteria document, 574 potentially applicable military standards and specifications were identified. One hundred fourteen were evaluated and 460 rejected. The rejected papers were either out of date or for low voltage or communications applications. Selected as a guide for this criteria document were:

MIL-C-17E, Cables, Radio Frequency, Flexible and Semi-Rigid.
MIL-C-915, Cable and Cord, Electrical, for Shipboard Use.
MIL-C-3702, Cable, Power, Electrical: Ignition, High Tension.
MIL-C-15479C, Cables, Power, Electrical, Submarine, Navy Harbor Defense.
MIL-C-18661, Cables, Power, Electrical, High Voltage.

MIL-W-16878D, Wire, Electrical, Insulated, High Temperature.

MIL-C-19638, Cables, Power, Electrical, Submarine, Navy Harbor Defense.

Data were taken from all seven of the above specifications with additions from NEMA Standards for high voltage applications such as safety, partial discharges (corona), impulse test, and dielectric withstanding voltage.

3.1.2 Cable Assemblies. The literature survey selected 574 potentially applicable military standards and specifications for the cable assembly criteria document. One hundred fourteen (114) were evaluated and four hundred sixty (460) rejected. The rejected papers were either out of date or for low voltage or communications applications. Selected as a guide for this criteria document were:

MIL-W-168780	Wire, Electrical, Insulated, High Temperature.
MIL-C-19638	Cables, Power, Electrical Submarine, Navy Harbor Defense.
MIL-C-28661	Cables, Power, Electrical, High Voltage.
MIL-C-36088	Cable Assembly, Special Purpose Electrical, Shockproof.
MIL-C-52286	Cable Assemblies, Power, Electrical.
IPCEA-NEMA	Standards Publication, Rubber Insulation Wire and Cable for the Transmission and Distribution of Electrical Energy.
USASI C86.1	Shockproof Cable Terminal and Receptacles for Use on X-Ray Equipment.

Data were taken from all seven of the above specifications with additions from NEMA Standards for high voltage applications, such as safety, partial cischarges (corona), impulse test, and dielectric withstanding voltage.

The majority of the paragraphs used in this high voltage cable assembly criteria document are taken from MIL-C-52286B and amendments. Paragraphs from this specification and other specifications are listed in Table 3.

TABLE 3. CABLE ASSEMBLY SPECIFICATION REFERENCES

PARAGRAPH	TITLE	REFERENCE	PARAGRAPH	REVISED
1.0	SCOPE	MIL-C-52286	1.0	X
2.0	APPLICABLE DOCUMENTS		2.0	X
3.0	REQUIREMENTS		3.0	
3.1	Detail requirements	Cable Criteria Document	3.1	
3.2	Qualification		3.2	
3.2.1	Requalification		3.2.1	X
3.3	Description	MIL-C-59886	3.1	X
3.3.1	Materials	Cable Criteria Document	3.3	X
3.4	Construction	MIL-C-36088	3.2	X
3.4.1	Cable body		3.2.1	X
3.4.2	Cable terminals		3.2.2	X
3.4.2.1	Plug	Connector Criteria Document	3.3.4.1.1	X
3.4.3	Receptacles		3.3.4.4.1.2	X
3.4.4	Shells and Coupling rings		3.3.5	X
3.4.4.1	Finish		3.4.4.1	X
3.4.5	Dummy connector	MIL-C-52286	3.7	X
3.4.5.1	Attaching means		3.7.1	X
3.4.5.1.1	Cotton twine		3.7.1.1	
3.4.5.1.2	Chain		3.7.1.2	
3.4.6	Caps		3.9	X
3.4.7	*Pins and sockets*		3.10	
3.4.7.1	Pins		3.10.1	
3.4.7.2	Sockets		3.10.2	
3.4.8	Coupling connections	Connector Criteria Document	3.4.5	X
3.4.8.1	Safety and Coupling rings		3.4.5.1	
3.4.8.2	Engagement seal		3.4.5.2	
3.4.8.3	Lubrication	New		
3.5	Bond between connectors and cables	MIL-C-52286	3.11	
3.6	Degree of closure		3.12	
3.7	Disengagement	Connector Criteria Document	3.6	
3.8	Electrical operational requirements		3.5	
3.8.1	Continuity		3.5.1	
3.8.2	Insulation resistance		3.8	
3.8.3	Dielectric withstanding voltage		3.9	
3.8.4	Corona	Cable Criteria Document	3.10	
3.8.5	Impulse test		3.5.8	
3.8.6	Ozone		3.8.6	
3.8.7	Electromagnetic compatibility		3.5.10	

TABLE 3 (Continued)

PARAGRAPH	TITLE	REFERENCE	PARAGRAPH	REVISED
3.8.8	Operating voltage	New		
3.8.9	Operating current			
3.8.10	Fault current			
3.9	Physical operational requirements	Cable Criteria Document	3.6	
3.9.1	Diameter measurements		3.6.1	
3.9.2	Out-of-roundness of jacket measurements		3.6.2	
3.9.3	Eccentricity of inner conductor		3.6.3	
3.10	Environmental	New		
3.10.1	Random vibration	Connector Criteria Document	3.23	X
3.10.2	Temperature		3.7	X
3.10.3	Moisture resistance		3.19	
3.10.4	Salt atmosphere	New		
3.10.5	Altitude	Connector Criteria Document	3.22	
3.10.6	Bonding	New		
3.11	Marking	Cable Criteria Document	3.10	X
3.12	Workmanship	Connector Criteria Document	3.25	
4.0	QUALITY ASSURANCE PROVISIONS	MIL-C-52286	4	
4.1	Responsibility for inspection		4.1	
4.1.1	Component and material inspection		4.1.1	
4.1.2	Sampling	New		
4.1.3	Test equipment and inspection Facilities	Cable Criteria Document	4.1.1	
4.2	Classification of inspection	MIL-C-52286	4.2	X
4.2.1	Inspection conditions	Cable Criteria Document	4.2.1	
4.3	Qualification inspection	MIL-C-52286	4.3	X
4.3.1	Examination		4.3.1	
4.3.2	Tests		4.3.2	
4.3.3	Qualification samples	Connector Criteria Document	4.3.1	X
4.4	Quality conformance inspection		4.4	
4.4.1	Inspection of product for delivery		4.4.1	X
4.4.2	Inspection lot		4.4.2	
4.4.2.1	Rejection lots		4.4.2.2	
4.4.2.2	Inspection		4.4.2.2.2	
4.4.2.2.1	Disposition of sample units		4.5.1.4	
4.4.2.2.2	Noncompliance			
4.5	Inspection of preparation for delivery	MIL-C-52286	4.7	
4.5.1	Quality conformance inspection of pack		4.7.1	
4.5.1.1	Unit of product		4.7.1.1	
4.5.1.2	Sampling		4.7.1.2	
4.5.1.3	Examination		4.7.1.3	X

TABLE 3 (Continued)

PARAGRAPH	TITLE	REFERENCE	PARAGRAPH	REVISED
4.6	Methods of examination and tests	Connector Criteria Document	4.6	
4.6.1	Visual and mechanical inspection		4.6.1	
4.6.2	Disengagement		4.6.2	
4.6.3	Hardness of insert or body material	MIL-C-52286	4.6.3.2	
4.6.4	Electrical tester	New		
4.6.4.1	Continuity	Cable Criteria Document	4.8.2	
4.6.4.2	Insulation resistance		4.8.5	
4.6.4.2.1	Procedure		4.8.5.1	X
4.6.4.2.2	Observation		4.8.5.2	
4.6.4.3	Dilectric withstanding voltage		4.8.4	
4.6.4.3.1	Apparatus		4.8.4.1	
4.6.4.3.2	Procedure		4.8.4.2	X
4.6.4.3.3	Observation		4.8.4.3	
4.6.4.3.4	Test voltage		4.8.4.4	
4.6.4.4	Corona		4.8.6	
4.6.4.5	Impulse voltage test		4.8.9	X
4.6.4.6	Ozone		4.8.20	
4.6.4.7	Electromagnetic compatability		4.8.21	X
4.6.4.8	Operating	MIL-C-52286	4.6.1	
4.6.4.8.1	Fault current	New		
4.6.5	Environmental tests	New		
4.6.5.1	Vibration	Connector Criteria Document	4.6.8	X
4.6.5.1.1	Procedure		4.6.8.1	
4.6.5.2	Temperature and humidity	MIL-C-52286	4.6.6	
4.6.5.2.1	Low-temperature storage and operation		4.6.6.1	
4.6.5.2.2	High-temperature and humidity storage and operation		4.6.6.2	
4.6.5.3	Salt atmosphere	New		
4.6.5.4	Altitude	Connector Criteria Document	4.6.18	X
4.6.5.5	Bonding	MIL-C-24231	4.3.5.5	X
5.0	PREPARATION FOR DELIVERY			
5.1	Preservation, packing and packaging	New		
5.1.1	Connector protection	New		
5.2	Packing	MIL-C-36088	5.2.2	
5.3	Marking		5.3	
5.3.1	Exterior container		5.3.1	
6.0	NOTES	MIL-C-52286	6.0	
6.1	Intended use		6.1	X
6.2	Ordering data		6.2	X
6.3	Preproduction model		6.3	

3.1.3 Capacitors. Three hundred eighty four (384), potentially applicable military standards and specifications and six (6) commercial specifications were identified. Selected as a guide for the criteria document on high voltage capacitors were MIL-C-19978D, and MIL-G-19978/3D, Capacitor, Fixed, Plastic (or Paper Plastic) Dielectric (Hermetically Sealed in Metal, Ceramic or Glass Cases), Established and Non-Established Reliability, General Specification For; and NEMA Publication Number SG 11-1955, Coupling Capacitors, Coupling Capacitor Potential Devices and Line Traps. Other pertinent specifications included:

MIL-C-25D,	Capacitors, Fixed, Paper Dielectric, Direct Current.
MIL-C-18312E,	Capacitors, Fixed, Metallized (Paper, Paper-Plastic, or Plastic Film) Dielectric, Direct Current.
MIL-C-39022C,	Capacitors, Fixed, Metallized (Paper, Paper-Plastic Film, Plastic Film), Dielectric, Direct Current.
ANSI C55.1, 1968	Shunt Power Capacitors.
ANSI C55.2, 1973	Series Capacitors for Transmission and Distribution Line Compensation

The majority of the paragraphs used in this high voltage capacitor criteria document are taken from MIL-C-19978D and amendments. Paragraphs that have been added, deleted, or modified are listed in Table 4. Likewise, the modification for MIL-C-19978/3D are listed in Table 5.

3.1.4 Connectors. The literature survey of connectors found one thousand two hundred twenty nine (1,229) potentially applicable military and commercial standards and specifications. Selected as a guide for this criteria document on high voltage connectors was MIL-C-5015G, Connectors, Electrical Circular Threaded, AN Type, General For. Other pertinent specifications included:

MIL-C-24217,	Connectors, Electrical, Deep Submergence, Submarine.
MIL-C-24231,	Connectors, Plugs, Receptacles, Adapters, Hull Inserts, Hull Insert Plugs, Pressure-Proof.
MIL-C-24368,	Connector Assemblies, Plugs and Receptacles, Electric, Power Transfer, Shore-to-Ship and Ship-to-Shore.

TABLE 4. MODIFICATIONS TO MIL-C-19978D

Paragraphs Deleted	Paragraphs Revised	Paragraphs Added
	1.1	
	1.2.1.1	
	1.2.1.4	
	1.2.1.5	
	2.2	
	3.4.2	3.5.5
	3.5.3.2	3.5.5.1
	3.17	3.5.5.2
		3.32
		3.33
4.6.1.3.5	4.4.3 Table VIII	4.7.27
	4.6.1.2.2 Table X	4.7.28
	4.6.1.3.1 Table XI	4.7.29
	4.6.1.3.2	
	4.6.1.3.3	
	4.6.1.3.4	
	4.7.8	
	4.7.22	
	6.5.5.1	
20.2.1	20.1	
	20.1.1	
	20.2	

TABLE 5. MODIFICATIONS TO MIL-C-19978/3C

Deleted	Revised	Added
	Figure 1	
	Figure 2	
Table V	Table II	
	Table III	
	Table IV	

3.1.4 (Continued)

MIL-C-26636	Contacts, Crimp Type, for Electrical Connectors.
MIL-C-55422,	Clip, Electrical, Grid and Anode.

The majority of the paragraphs used in this high voltage connector criteria document were patterned after MIL-C-5015G. A few paragraphs were taken directly from the original text, the rest were either modified or deleted.

3.1.5 Converters. During the preparation of the high voltage/high power aircraft converter criteria document, seventy one (71) potentially applicable military standards and specifications were identified for converters and three hundred eight (308) for filters. Five (5) were evaluated and three hundred seventy four (374) rejected. The rejected papers were either out of date or for low voltage or communications applications. Selected as a guide for this criteria document were:

Conversion Equipment

MIL-C-7115D,	Converters, Aircraft, General Specification for.
IEEE-STD-444,	IEEE Standard Practices and Requirements for Thyristor Converters for Motor Drives.

Filters

MIL-STD-1395,	Filters and Networks, Selection and Use of.
MIL-F-12548,	Filter, Low Pass F-215 ( )/G.
	Filter, High Pass F-216 ( )/G.
MIL-F-18327,	Filters, High Pass, Band Pass, Band Suppression, and Dual Functioning, General Specification for.

Many of the paragraphs used in this high voltage/high power airborne converter criteria document were taken from MIL-C-7115D and amendments. Paragraphs from this specification are listed in Table 6. Revised paragraphs are noted in the Table 6.

TABLE 6

HIGH VOLTAGE, HIGH POWER AIRCRAFT CONVERTERS

Reference MIL-C-7115

Paragraph	Title	MIL-C-7115 Reference	Revised
1.	SCOPE	1	
1.1	Scope	1.	
1.2	Classification	1.2	
1.2.1	Family	New	
1.2.2	Types	1.2.1	
1.2.3	Classes	1.2.2	X
2.	APPLICABLE DOCUMENTS	2	
2.1		2.1	X
2.2	Other publications	2.2	X
3.	REQUIREMENTS	3.	
3.1	Qualification	3.1	X
3.2	Specification sheets	3.2	X
3.2.1	First article	New	
3.2.2	Information to be furnished with first article sample	New	
3.3	Metals, parts, and processes	3.3	
3.3.1	Selection of materials, parts, and processes	3.3.1	
3.3.1.1	Substitution of materials	New	
3.3.1.2	Flammable materials	New	
3.3.1.3	Corrosive materials	New	
3.3.2	Electrical insulating materials	3.3.2	X
3.3.2.1	Laminated phenolic	New	
3.3.2.2	Molded phenolic or melamine	New	
3.3.2.3	Ceramic	New	
3.3.2.4	Laminated plastic sheet	New	
3.3.2.5	Materials quality	New	
3.3.3	Metals	3.3.3	X

(Continued)

TABLE 6 (Continued)

Paragraph	Title	MIL-C-7115 Reference	Revised
3.3.3.1	Corrosive resistance	3.3.3.1	
3.3.3.2	Dissimilar metals	3.3.3.2	X
3.3.3.3	Solder and soldering flux	New	
3.3.3.4	Screws, nuts, bolts,and washer	New	
3.3.3.5	Corona protection	New	
3.3.4	Toxic materials	3.3.4	
3.3.5	Standard parts	3.3.5	
3.3.6	Nonstandard parts and materials	3.3.6	
3.3.7	Interchangeability	3.3.7	
3.3.8	Wire	New	
3.3.8.1	Insulated wire	New	
3.3.8.2	Wire support	New	
3.4	Design and construction	3.4	
3.4.1	Functional description	New	
3.4.2	Performance	3.4.1	X
3.4.2.1	Input voltage	New	
3.4.2.2	Alternating current power source	New	
3.4.2.2.1	Power factor	3.4.5	X
3.4.2.2.2	Input current balance	3.4.7	
3.4.2.2.3	Reduced input frequency	3.4.9	X
3.4.2.3	MHD power source	New	
3.4.2.4	Input voltage transient	New	
3.4.2.5	Output voltage	New	
3.4.2.6	Output voltage transient	New	
3.4.2.7	Ripple and modulation	New	
3.4.2.8	Rated load	New	
3.4.2.9	Short circuit capability	3.4.3	X
3.4.2.10	Overload	3.4.2(j)	X
3.4.2.11	Efficiency	New	
3.4.2.12	Signal processor	New	
3.4.2.13	Reflected transients	New	
3.4.2.14	Isolation	New	
3.4.2.15	Remote sensing	New	

(Continued)

TABLE 6 (Continued)

Paragraph	Title	MIL-C-7115 Reference	Revised
3.4.3	Operational conditions	New	
3.4.3.1	Temperature and altitude	3.4.2(a)	X
3.4.3.2	Humidity	3.4.2(b)	X
3.4.3.3	Sand and dust	3.4.2(c)	X
3.4.3.4	Salt spray	3.4.2(d)	X
3.4.3.5	Fungus	3.4.2(e)	X
3.4.3.6	Shock	New	
3.4.3.7	Vibration	New	
3.4.3.8	Flammability	New	
3.4.3.9	Nuclear radiation	3.4.2(h)	
3.4.4	Mechanical construction	New	
3.4.4.1	Seal	New	
3.4.4.1.1	Liquid-filled units	New	
3.4.4.1.2	Gas-filled units	New	
3.4.4.1.3	Pressure-vacuum transducer	New	
3.4.4.1.4	Liquid temperature transducer	New	
3.4.4.1.5	Pressure vacuum bleeder	New	
3.4.4.1.6	Tanks	New	
3.4.4.2	Cooling	3.4.14	X
3.4.4.3	Fans, pumps and control	3.4.14.1	X
3.4.4.4	Lifting, moving, and jacking facilities	New	
3.4.4.4.1	Safety factor	New	
3.4.4.4.2	Lifting facility	New	
3.4.4.4.3	Moving facility	New	
3.4.4.4.4	Jacking facility	New	
3.4.4.4.5	Mounting	3.4.19	X
3.4.4.4.6	Mounting studs	New	
3.4.4.5	Mounting and terminal screws and mounting inserts	New	
3.4.4.6	Screw terminals	New	
3.4.4.7	Terminal strength	New	
3.4.5	Electrical construction	3.4.13	X
3.4.5.1	Internal wire leads	New	
3.4.5.2	Wire bundle ties and clamps	New	
3.4.5.3	Terminals	New	

(Continued)

TABLE 6 (Continued)

Paragraph	Title	MIL-C-7115 Reference	Revised
3.4.5.3.1	Solder terminals	3.4.13.1	X
3.4.5.3.2	Case as a terminal	New	
3.4.5.3.3	Bushings	New	
3.4.5.3.4	Terminal insulators	New	
3.4.5.3.5	Connectors	3.4.18	X
3.4.5.4	Corona protected bushing insulator	New	
3.4.5.5	Solderability	New	
3.4.5.6	Resistance to soldering heat	New	
3.4.5.7	Potting, filling, or encapsulating material	New	
3.4.5.8	Grounding	New	
3.4.5.9	Capacitors	3.4.10.1	X
3.4.5.10	Surge arrestors	New	
3.5	High voltage design and test	New	
3.5.1	Insulation resistance	New	
3.5.2	Dielectric withstanding voltage	New	
3.5.3	Partial discharges	New	
3.5.4	Impulse	New	
3.5.4.1	Terminals not being tested	New	
3.5.5	Electromagnetic compatibility	3.4.15	X
3.6	Life	3.4.12	X
3.7	Marking	3.5	
3.8	Safety wiring and staking	3.6	
3.9	Workmanship	3.8	
4.	QUALITY ASSURANCE PROVISIONS	4	
4.1	Responsibility for inspection	4.1	X
4.1.1	Test equipment and inspection facilities	New	
4.2	Classifications of inspections	4.2	X
4.3	Materials inspection	New	
4.4	Inspection conditions	4.3.2	X
4.4.1	Test frequency	New	
4.4.2	Test voltage	New	

(Continued)

TABLE 6 (Continued)

Paragraph	Title	MIL-C-7115 Reference	Revised
4.5	Qualification inspection	4.3	X
4.5.1	Sample size	New	
4.5.2	Inspection routine	New	
4.5.3	Failure	New	
4.5.4	Test reports	4.3.1	
4.5.5	Rejection and retest of qualifications and quality conformance units	4.3.3	
4.5.6	Retention of qualification	New	
4.6	Quality conformance inspection	4.3.4	X
4.6.1	Inspection of product for delivery	4.4.1	X
4.6.1.1	Inspection lot	New	
4.6.1.2	Rejected lots	New	
4.6.1.3	Disposition of units	New	
4.6.2	Inspection of preparation for delivery	New	
4.7	Methods of examination and test	4.5	X
4.7.1	Visual and mechanical examination	4.6.1	X
4.7.1.1	External	New	
4.7.1.2	Internal	New	
4.7.1.3	Post-test	New	
4.8	Electrical performance	4.6	X
4.8.1	Test conditions	4.5	X
4.8.1.1	Altitude and temperature	4.5(b)	X
4.8.1.2	Input voltage	4.5(e)	X
4.8.1.3	Cooling	New	
4.8.1.4	Warm up	4.5(d)	X
4.8.1.5	Instrumentation	4.2.2	
4.8.1.6	Electrical measurements	4.6.5	X
4.8.1.7	Temperature measurements	4.6.5.1	X
4.8.2	Steady-state output characteristics	4.6.2.1	X
4.8.2.1	Ripple and modulation	4.6.9	X
4.8.2.2	Operating period	New	
4.8.2.3	Input power factor	4.6.6	X
4.8.2.4	Efficiency	4.6.7	X

(Continued)

TABLE 6 (Continued)

Paragraph	Title	MIL-C-7115 Reference	Revised
4.8.2.5	Input current balance	4.6.8	X
4.8.3	Transient characteristics	4.6.13	X
4.8.3.1	Input voltage transient	4.6.13	X
4.8.3.2	Short circuit test	4.6.3	X
4.8.3.3	Overload	4.6.2.2	
4.8.3.4	Overload at maximum ambient	4.6.2.3	
4.8.4	Signal processor	New	
4.8.5	Reflected transients	New	
4.8.6	Isolation	New	
4.8.7	Remote sensing	New	
4.9	Environmental tests	New	
4.9.1	Thermal shock	4.6.16	X
4.9.2	Altitude	New	
4.9.3	Humidity	4.6.20	X
4.9.4	Sand and dust	4.6.26	X
4.9.5	Salt spray	4.6.24	X
4.9.6	Fungus	4.6.23	X
4.9.7	Shock	4.6.21	X
4.9.7.1	Specified pulse	New	
4.9.7.2	High impact	New	
4.9.8	Vibration	4.6.22	X
4.9.8.1	Vibration, low frequency	New	
4.9.8.2	Vibration, high frequency	New	
4.9.9	Flammability	New	
4.9.10	Nuclear radiation	4.6.27	
4.10	Mechanical and electrical tests	New	
4.10.1	Seal	New	
4.10.1.1	Liquid-filled units	New	
4.10.1.2	Gas-filled units	New	
4.10.2	Auxiliary components	New	
4.10.2.1	Transducers	New	
4.10.2.2	Motors	New	
4.10.3	Tank design proof pressure	New	

(Continued)

TABLE 6 (Continued)

Paragraph	Title	MIL-C-7115 Reference	Revised
4.10.3.1	Tank design, burst	New	
4.10.3.2	Internal vacuum	New	
4.10.4	Cooling	New	
4.10.5	Terminal strength	New	
4.10.5.1	Pull	New	
4.10.5.1.1	Solid-wire and insulated wire lead terminals	New	
4.10.5.1.2	Solder terminals	New	
4.10.5.2	Twist and bend	New	
4.10.5.2.1	Solid-wire terminals	New	
4.10.5.2.2	Flat solder terminals	New	
4.10.6	Bushings	New	
4.10.7	Solderability	New	
4.10.7.1	Solder bath method	New	
4.10.7.2	Soldering iron method	New	
4.10.8	Resistance to soldering heat	New	
4.10.8.1	Solder bath method	New	
4.10.8.2	Soldering iron method	New	
4.10.9	Grounding and bonding	New	
4.10.9.1	Grounding	New	
4.10.9.2	Lightning and electromagnetic pulse	New	
4.10.10	Capacitors	4.6.4.1	
4.10.11	Surge arrestors	New	
4.11	H.V. evaluation tests	New	
4.11.1	Insulation resistance	New	
4.11.2	Dielectric withstanding voltage	4.6.4	X
4.11.2.1	Atmospheric pressure	New	
4.11.2.2	Altitude	New	
4.11.2.3	At reduced voltage	New	
4.11.3	Partial discharges	New	
4.11.3.1	Input circuit	New	
4.11.3.2	Output circuit	New	

(Continued)

TABLE 6 (Continued)

Paragraph	Title	MIL-C-7115 Reference	Revised
4.11.3.3	Operational	New	
4.11.4	Impulse	New	
4.11.4.1	Reduced full-wave test	New	
4.11.4.2	Chopped-wave test	New	
4.11.4.3	Connections for impulse tests	New	
4.11.4.4	Terminals not being tested	New	
4.11.4.5	Wave to be used for impulse tests	New	
4.11.4.6	Voltage	New	
4.11.5	Electromagnetic interference	4.6.14	X
4.12	Life	4.6.25	X
5.	PREPARATION FOR DELIVERY	5	
5.1	Preservation-packaging	5.1	X
5.1.1	Level A	New	
5.1.1.1	Cleaning	New	
5.1.1.2	Drying	New	
5.1.1.3	Preservation application	New	
5.1.1.4	Unit packaging	New	
5.1.1.5	Intermediate packaging	New	
5.1.2	Level C	New	
5.2	Packing	New	
5.2.1	Level A	New	
5.2.2	Level B	New	
5.2.3	Level C	New	
5.2.4	Unitized loads	New	
5.2.4.1	Level A	New	
5.2.4.2	Level B	New	
5.2.4.3	Level C	New	
5.3	Marking	5.3	X
5.4	General	New	
5.4.1	Exterior containers	New	
5.4.2	Air Force requirements	New	

(Continued)

TABLE 6 (Continued)

Paragraph	Title	MIL-C-7115 Reference	Revised
6.	NOTES	6	
6.1	Intended use	6.1	X
6.2	Ordering data	6.2	
6.3	Qualification	6.3	X
6.3.1	Submission of drawings	6.3.1	
6.3.2	Failure of samples	6.3.2	
6.4	Service test	6.4	
6.5	Definition	6.5	

3.1.6 Power Characteristics. Selected as a guide for this criteria document was MIL-STD-704, Aircraft Electrical Power Characteristics. The majority of the paragraphs used in this criteria document are taken from MIL-STD-704 and amendments. Paragraphs that have been added, deleted, or modified are listed in Table 7.

3.1.7 Power Sources. Power sources include rotating machines and magnetohydrodynamic (MHD) generators. The literature survey identified two hundred twenty seven (227) potentially applicable military standards and specifications. Sixteen (16) were evaluated and two hundred eleven (211) rejected. The rejected papers were either out of date or for low voltage commercial applications. Selected as a guide for this criteria document were:

MIL-G-3087,	Generator Sets, Steam Turbine, Direct and Alternating Current, Naval Shipboard Use.
MIL-G-7789,	Generator, Pulse AN/UPM-55.
MIL-G-19650,	Generator Sets, Steam Turbine, Direct Drive, 2000 kw.
MIL-G-24464,	Generator Set, Gas Turbine, Magnetic Minesweeping, 1750 kw.
MIL-G-28670,	Generator Set, Gas Turbine Engine, 750 kw, 50/60 Hertz, Prime, Utility.
MIL-G-45799,	Generator, Pulse (2 μsec and 15 MC).
MIL-G-46800,	Generator, Pulse (0.25 μ sec).
MIL-G-46805,	Generator, Pulse.
MIL-G-50349,	Generator, Pulse.
MIL-G-60186,	Generator, Pulse.

There were no standards or specifications for the magnetohydrodynamic generator. Requirements and qualification test data were accumulated from the literature search on magnetohydrodynamic power sources. The format was copied after the alternator specification with appropriate modifications.

TABLE 7. POWER CHARACTERISTICS
COMPARISON TO MIL-STD-704

PARAGRAPH	TITLE	MIL-STD-704 PARAGRAPH	REVISED
1	GENERAL	1	
1.1	Scope	1.1	X
1.2	Purpose	1.2	X
2	REFERENCED DOCUMENTS	2	
3	DEFINITIONS	3	
3.2	AC power characteristics	3.2	X
3.3	AC voltage	3.3	
3.3.1	Nominal AC voltage	3.3.1	X
3.4	Crest factor	3.4	
3.5	DC power characteristics	3.5	
3.5.1	Nominal dc voltage	3.5.1	X
3.6	Distortion	3.6	
3.6.1	Distortion factor	3.6.1	
3.6.2	Distortion spectrum	3.6.2	
3.7	Electrical power characteristics	3.7	
3.8	Electric power system	3.8	X
3.9	Electromagnetic compatibility	3.9	
3.10	Frequency	3.11	
3.10.1	Nominal frequency	3.11.1	X
3.10.2	Frequency drift	3.11.2	
3.10.2.1	Frequency drift rate	3.11.2.1	
3.10.3	Frequency modulation	3.11.3	
3.10.4	Frequency transient	3.11.4	
3.11	Overvoltage and undervoltage	3.12	X
2.12	Ripple amplitude	3.13	
3.13	Steady stage	3.14	
3.14	Utilization equipment	3.15	
3.14.1	Utilization equipment terminals	3.15.1	
3.15	Voltage phase difference	3.16	

TABLE 7 (Continued)

PARAGRAPH	TITLE	MIL-STD-704 PARAGRAPH	REVISED
3.16	Voltage surge	3.17	X
3.17	Voltage spike	3.18	X
3.18	Voltage unbalance	3.19	
3.19	Reference ground	3.20	X
3.20	Power sensitivity	3.21	
4	GENERAL REQUIREMENTS	4	
4.1	System equipment compatibility	4.1	
4.2	Conformance tests	4.3	X
5	DETAIL REQUIREMENTS	5	
5.1	AC power characteristics	5.1	X
5.1.1	Steady state	5.1.1	
5.1.1.1	AC voltage magnitude	5.1.1.1	X
5.1.1.2	Voltage unbalance	5.1.1.2	X
5.1.1.3	Voltage phase difference	5.1.1.3	X
5.1.1.4	Phase sequence	5.1.1.4	X
5.1.1.5	AC waveform distortion	5.1.1.5	X
5.1.1.6	Amplitude modulation	5.1.1.6	X
5.1.1.7	System frequency	5.1.1.7	X
5.1.1.8	Frequency modulation	5.1.1.8	
5.1.1.9	Frequency drift	5.1.1.9	X
5.1.2	Transient	5.1.2	
5.1.2.1	Voltage surge	5.1.2.1	
5.1.2.2	Voltage spike	5.1.2.2	X
5.1.3	Frequency transient limits (frequency surge)	5.1.3	X
5.1.4	Overvoltage and undervoltage	5.1.4	X
5.1.5	Out-of-tolerance frequency (over- and under-frequency)	5.1.5	X
5.2	DC power characteristics	5.2	X
5.2.1	Steady state	5.2.1	
5.2.1.1	DC voltage magnitude	5.2.1.1	X
5.2.1.2	DC distortion	5.2.1.2	X

TABLE 7 (Continued)

PARAGRAPH	TITLE	MIL-STD-704 PARAGRAPH	REVISED
5.2.2	Transient	5.2.2	
5.2.2.1	Voltage surge	5.2.2.1	X
5.2.2.2	Voltage spike	5.2.2.2	
5.2.3	Overvoltage and undervoltage	5.2.3	X
5.3	Ground support power characteristics	5.3	X
5.3.1	AC voltage	5.3.1	
5.3.1.1	AC voltage magnitude	5.3.1.1	X
5.4	System operation of utilization equipment	5.4	
5.4.1	Power types	5.4.1	X
5.4.2	Equipment performance	5.4.2	X
5.4.3	Precision power	5.4.3	
5.4.4	Partial power failure	5.4.4	
5.4.5	Power sensitivity tests	5.4.5	
5.4.5.1	Voltage spike	5.4.5.1	X
6	NOTES	6	
6.1	Total system characteristics	6.1	X
6.2	Spikes	6.2	X
6.3	Power sensitivity and system conformance tests	6.3	X
6.4	DC distortion: individual equipment vs. system effects	6.4	X
6.5	Amplitude modulation	6.5	X
6.6	International Standardization Agreement	6.7	

3.1.8 Transformers and Inductors. During the preparation of high voltage transformers and inductors criteria documents, two hundred thirty nine (239) potentially applicable military standards and specifications were identified. Eleven were evaluated and 218 rejected. The rejected papers were either out of date or for low voltage or communications applications. Selected as a guide for this criteria document were:

MIL-T-27	Transformers and Inductors.
American National Standards	
ANSI C 57.12.00-1977	General Requirements for Distribution, Power and Regulation Transformers.
ANSI C 57.12.10-1977	Requirements for Transformers 230,000 Volts and Below, 833/958 through 8333/10,417 KVA Single-Phase and 750/862 through 60,000/ 80,000/100,000 KVA, Three-Phase
ANSI C 57.12.30-1977	Requirements for Load-Tap-Changing Transformers 230,000 volts and below, 3750/4687 through 60,000/80,000/100,000 KVA, Three-Phase.
ANSI C 57.12.90-1973	Test Code for Distribution, Power and Regulating Transformers.
ANSI C 57.12.90 a	Distribution and Power Transformer Short-Circuit Test Code.
ANSI C 57.21-1971	Requirements, Terminology and Test Code for Shunt Reactors.
Appendix C 57.97 (1971)	Guide for Preparation of Specifications for Large Power Transformers With and Without Load-Tap-Changing.

I.E.E. Standards

Pub. No. ST.20-1972	Dry Type Transformers for General Application.
IEEE Std. 93-1968	IEEE Guide for Transformer-Impulse Tests.
IEEE Std. 345-1972	IEEE Standard Standard Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers.

The majority of the paragraphs used in this high voltage transformer and inductor criteria document are taken from MIL-T-27 and amendments. Paragraphs from this specification are listed in Table 8. Revised paragraphs are noted in Table 8.

3.2 High Voltage Tests. High voltage tests and requirements added to the equipment test requirements include: safety, partial discharge test, impulse voltage test, and dielectric withstanding voltage (DWV) test. Partial discharge tests are added to assure the materials have few or no large voids within the dielectric between the high voltage conductors and frame. The DWV test was decreased from 2V + 1, to 1.6V where V is the operating voltage in KV. This new value can be justified as follows:

1) The transformer or inductor assembly may have an overall life of 10 years but the total operating time will be less than 2% time (1,750 hours).

2) Transformer and inductor assemblies will be life tested.

Impulse testing is added to assure that the electrical insulation will not be damaged by electromagnetic pulses, transients, or lightning. Peak impulse voltage for this test is generally 2.5 times the DWV test.

TABLE 8 HIGH VOLTAGE TRANSFORMERS AND INDUCTORS

Reference to MIL-T-27

Paragraph	Title	MIL-T-27 Reference	
1.0	Scope	1.0	
1.1	Scope	1.1	X
1.2	Classification	1.2	
1.2.1	Type Designation	1.2.1	X
1.2.1.1	Component	1.2.1.1	
1.2.1.2	Grade	1.2.1.2	
1.2.1.2.1	Grades 7, 9, 10	1.2.1.2.1	
1.2.1.2.2	Grade 8	1.2.1.2.2	X
1.2.1.3	Class	1.2.1.3	
1.2.1.4	Family	1.2.1.4	X
1.2.1.5	Envelope and Mounting Dimensions	1.2.1.5	X
1.2.1.6	Identification Number	1.2.1.6	X
2.	Applicable Documents	2.	
2.1	Publications	2.1	X
2.2	Other Publications	2.2	X
3.	Requirements	3	
3.1	Specification Sheets	3.1	X
3.2	Qualification	3.2	
3.3	First Article	3.3	X
3.3.1	Information to be Furnished with First Article Sample	3.3.1	
3.4	Materials	3.4	
3.4.1	Substitution of Materials	3.4.1	
3.4.2	Flammable Materials	3.4.2	
3.4.3	Corrosive Materials	3.4.3	
3.4.4	Insulating Materials	3.4.4	
3.4.4.1	Laminated Phenolic	3.4.4.1	
3.4.4.2	Molded Phenolic or Melamine	3.4.4.2	
3.4.4.3	Ceramic	3.4.4.3	
3.4.4.4	Laminated Plastic Sheet	New	
3.4.5	Wire	3.4.5	
3.4.5.1	Magnet Wire	3.4.5.1	X
3.4.5.2	Insulated Wire	3.4.5.2	X

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revised
3.4.6	Solder and Solder Flux	3.4.6	
3.4.7	Screws, Nuts, Bolts and Washers	3.4.7	X
3.5	Design and Construction	3.5	
3.5.1	Mounting and Terminal Screws and Mounting Inserts	3.5.1	X
3.5.2	Terminals	3.5.2	
3.5.2.1	Solder Terminals	3.5.2.1	
3.5.2.2	Case as Terminal	New	
3.5.2.3	Bushings	New	
3.5.2.4	Terminal Insulator	New	
3.5.2.5	Connectors	New	
3.5.2.6	Screw Terminals	3.5.2.4	
3.5.2.7	Corona Protected Bushing Insulator	New	
3.5.3	Lifting, Moving and Jacking Facilities	New	
3.5.3.1	Safety Factor	New	
3.5.3.2	Lifting Facilities	New	
3.5.3.3	Moving Faciliities	New	
3.5.3.4	Jacking Facilities	New	
3.5.3.5	Mounting	New	
3.5.3.6	Mounting Studs	3.5.3	
3.5.4	Internal Lead Wires	3.5.4	
3.5.5	Coil and Coil Mounting	3.5.5	X
3.5.6	Paint Composition and Color	3.5.6	X
3.5.7	Potting, Filling or Encapsulating Material	3.5.7	
3.6	Solderability	3.6	
3.7	Resistance to Solvents	3.7	
3.8	Thermal Shock	3.8	
3.9	Resistance to Soldering Heat	3.9	
3.10	Terminal	3.10	
3.11	Seal	3.11	
3.11.1	Liquid-Filled Units	3.11.1	
3.11.2	Gas-Filled Units	3.11.2	
3.11.3	Pressure-Vacuum Transducer	New	

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revised
3.11.4	Liquid-Temperature Transducer	New	
3.11.5	Pressure-Vacuum Bleeder	New	
3.11.6	Tanks	New	
3.11.7	Fans, Pumps and Control	New	
3.11.8	Surge Arrestor	New	
3.11.9	All Other Units	3.11.3	
3.12	Dielectric Withstanding Voltage	3.12	
3.13	Individual Voltage	3.13	
3.14	Insulation Resistance	3.14	X
3.15	Electrical Characteristics	3.15	
3.15.1	Polarity	New	
3.15.2	Turns Ratio	New	
3.15.3	D.C. Resistance and Resistive Unbalance	New	
3.15.4	Primary Impedance	New	
3.15.5	Core Loss	New	
3.15.6	Insulation Power Loss	New	
3.15.7	Bushings	New	
3.15.8	No Load	New	
3.15.9	Efficiency and Regulation	New	
3.15.10	Short Circuit	New	
3.15.11	Inductance and Inductance Unbalance	New	
3.15.12	Harmonic Distortion	New	
3.15.13	Self-Resonant Frequency	New	
3.15.14	Storage Factor	New	
3.15.15	Wave Shape	New	
3.16	Temperature Rise	3.16	
3.17	Partial Discharges	3.17	X
3.18	Impulse	New	
3.18.1	Terminals Not Being Tested	New	
3.19	Electromagnetic Compatibility	New	
3.20	Altitude	New	
3.21	Salt Spray	3.18	
3.22	Vibration	3.19	
3.23	Shock	3.20	

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revised
3.24	Winding Continuity	3.21	
3.25	Immersion	3.22	
3.26	Moisture Resistance	3.23	
3.27	Overload	3.24	
3.28	Visual and Mechanical Examination	3.25	
3.29	Flammability	3.26	
3.30	Life	3.27	X
3.31	Fungus	3.28	
3.32	Marking	3.29	X
3.32.1	Family 03	3.29.1	
3.32.2	Families 04 and 37	3.29.2	
3.32.3	Families 04 and 41	3.29.5	
3.32.4	Terminal Identification	3.29.6	X
3.33	Workmanship	3.30	
4	Quality Assurance Provisions	4	
4.1	Responsibility for Inspection	4.1	
4.1.1	Test Equipment and Inspection Facilities	4.1.1	
4.2	Classification of Inspections	4.2	
4.3	Materials Inspection	4.3	X
4.4	Inspection Conditions	4.4	X
4.4.1	Test Frequency	4.4.1	X
4.4.2	Test Voltage	4.4.2	
4.5	Qualification Inspection	4.5	
4.5.1	Qualification of Transformer and Inductors Based on Complete Testing	4.5.1	
4.5.1.1	Sample Size	4.5.1.1	X
4.5.1.2	Inspection Routine	4.5.1.2	X
4.5.1.3	Failure	4.5.1.3	
4.5.2	Qualification Inspection of Transformers and Inductors Based on Similarity	4.5.2	
4.5.2.1	Sample Size	4.5.2.1	X
4.5.2.2	Inspection Routine	4.5.2.2	X
4.5.2.3	Failure	4.5.2.3	X

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revised
4.5.3	Retention of Qualification	4.5.3	X
4.6	First Article Inspection	4.6	X
4.7	Quality Performance Inspection	4.7	
4.7.1	Inspection of Product for Delivery	4.7.1	X
4.7.1.1	Inspection Lot	4.7.1.1	X
4.7.1.2	Group A Inspection	4.7.1.2	X
4.7.1.2.1	Rejection Lot	4.7.1.2.2	X
4.7.1.2.2	Group B Inspection	4.7.1.3	X
4.7.1.2.3	Rejection Lots	4.7.1.3.2	X
4.7.1.2.4	Disposition of Units	4.7.1.3.3	X
4.7.2	Inspection of Preparation for Delivery	4.7.2	X
4.8	Method of Examination and Test	4.8	
4.8.1	Visual and Mechanical Examination	4.8.1	
4.8.1.1	External	4.8.1.1	
4.8.1.1.1	Post-Test	4.8.1.1.1	
4.8.1.2	Internal	4.8.1.2	
4.8.2	Solderability	4.8.2	
4.8.2.1	Solder Bath Method	4.8.2.1	X
4.8.2.2	Soldering Iron Method	4.8.2.2	X
4.8.3	Resistance to Solvents	4.8.3	
4.8.4	Thermal Shock	4.8.4	
4.8.5	Resistance to Soldering Heat	4.8.5	
4.8.5.1	Solder Bath Method	4.8.5.1	
4.8.5.2	Soldering Iron Method	4.8.5.2	
4.8.6	Terminal Strength	4.8.6	
4.8.6.1	Pull	4.8.6.1	
4.8.6.1.1	Solid-Wire and Insulated-Wire Lead Terminals	4.8.6.1.1	X
4.8.6.1.2	Solder Terminals	4.8.6.1.2	X
4.8.6.2	Twist or Bend	4.8.6.2	
4.8.6.2.1	Solid Wire Lead Terminals	4.8.6.2.1	
4.8.6.2.2	Flat Solder Terminals	4.8.6.2.2	
4.8.6.3	Torque	4.8.6.3	X

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revised
4.8.7	Seal	4.8.7	
4.8.7.1	Liquid-Filled Units	4.8.7.1	X
4.8.7.2	Gas-Filled Units	4.8.7.2	X
4.8.7.3	Auxiliary Components	New	
4.8.7.3.1	Transducers	New	
4.8.7.3.2	Motors	New	
4.8.7.3.3	Surge Arrestors	New	
4.8.8	Dielectric Withstanding Voltage	4.8.8	
4.8.8.1	At Atmospheric Pressure	4.8.8.1	X
4.8.8.1.1	For Special Designs	4.8.8.1.1	X
4.8.8.2	Altitude	4.8.8.2	X
4.8.8.3	At Reduced Voltage	4.8.8.3	X
4.8.9	Induced Voltage	4.8.9	X
4.8.9.1	All Transformers and Inductors	4.8.9.1	X
4.8.9.2	Pulse Transformers and Inductors	4.8.9.2	X
4.8.9.3	Saturating Core Power Transformers	4.8.9.3	X
4.8.10	Insulation Resistance	4.8.10	X
4.8.11	Electrical Characteristics	4.8.11	
4.8.11.1	No Load	4.8.11.1	
4.8.11.2	Efficiency and Regulation	New	
4.8.11.2.1	Unrectified Units	4.8.11.2.1	
4.8.11.2.2	Rectified Units	4.8.11.2.2	
4.8.11.2.3	Efficiency	New	
4.8.11.2.4	Regulation	New	
4.8.11.2.4.1	Measurement	New	
4.8.11.2.4.2	Determination of Transformer Regulation	New	
4.8.11.2.4.3	Two-Winding Transformers	New	
4.8.11.2.4.4	Three-Winding Transformers	New	
4.8.11.3	DC Resistance and Resistance Unbalance	4.8.11.3	
4.8.11.4	Inductance and Unductive Unbalance	4.8.11.4	
4.8.11.5	Harmonic Distortion	4.8.11.5	
4.8.11.6	Primary Impedance	4.8.11.6	
4.8.11.7	Self-Resource Frequency	4.8.11.8	

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revised
4.8.11.8	Electromagnetic Compatibility	New	
4.8.11.8.1	Electrostatic Shielding	4.8.11.11	
4.8.11.8.2	Magnetic Shielding	4.8.11.12	
4.8.11.8.3	Alternate Test	4.8.11.12.1	
4.8.11.9	Polarity	4.8.11.14	
4.8.11.9.1	Alternate Methods	New	
4.8.11.9.2	Polarity by Inductive Kick	New	
4.8.11.9.3	Polarity by Alternating-Voltage Test	New	
4.8.11.9.4	Polarity Test on Three-Phase Transformer	New	
4.8.11.10	Storage Factor	4.8.11.15	
4.8.11.11	Wave Shape	4.8.11.16	
4.8.11.12	Turns Ratio or Voltage Ratio	4.8.11.17	
4.8.11.13	Short Circuit Test	4.8.11.19	
4.8.11.14	Core Loss	New	
4.8.11.14.1	Excitation Loss of Three-Phase Transformer	New	
4.8.11.15	Insulation Power Loss	New	
4.8.11.16	Bushings	New	
4.8.11.17	Terminals Not Being Tested	New	
4.8.11.18	Altitude	New	
4.8.11.19	Temperature Rise	4.8.12	X
4.8.12	Partial Discharges	4.8.13	X
4.8.12.1	Intrawinding Insulation	4.8.13.1	X
4.8.12.2	Interwinding Insulation	4.8.13.2	X
4.8.13	Impulse	New	
4.8.13.1	Reduced Full-Wave Test	New	
4.8.13.2	Chopped-Wave Test	New	
4.8.13.3	Front-of-Wave Test	New	
4.8.13.4	Connections for Impulse Test	New	
4.8.13.5	Terminals Not Being Tested	New	
4.8.13.6	Wave to be Used for Impulse Test	New	
4.8.13.7	Voltage	New	
4.8.14	Salt Spray	4.8.14	
4.8.15	Vibration	4.8.15	
4.8.15.1	Vibration, Low Frequency	4.8.15.1	X
4.8.15.2	Vibration, High Frequency	4.8.15.2	X

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revised
4.8.16	Shock	4.8.16	
4.8.16.1	Specified Pulse	4.8.16.1	
4.8.16.2	High-Impact	4.8.16.2	
4.8.17	Winding Continuity	4.8.17	
4.8.18	Immersion	4.8.18	
4.8.19	Moisture Resistance	4.8.19	X
4.8.20	Overload	4.8.20	X
4.8.20.1	Maximum Voltage	4.8.20.1.2	
4.8.20.2	Inductors	4.8.20.2	X
4.8.20.3	Saturable Core Reactors	4.8.20.3	X
4.8.21	Flammability	4.8.21	
4.8.22	Life	4.8.22	X
4.8.23	Fungus	4.8.23	
5	Preparation for Delivery	5	
5.1	Preservation - Packaging	5.1	
5.1.1	Level A	5.1.1	
5.1.1.1	Cleaning	5.1.1.1	
5.1.1.2	Drying	5.1.1.2	
5.1.1.3	Preservative Application	5.1.1.3	
5.1.1.4	Unit Packaging	5.1.1.4	
5.1.1.5	Intermediate Packaging	5.1.1.5	
5.1.2	Level C	5.1.2	
5.2	Packing	5.2	
5.2.1	Level A	5.2.1	X
5.2.2	Level B	5.2.2	
5.2.3	Level C	5.2.3	
5.2.4	Unitized Loads	5.2.4	
5.2.4.1	Level A	5.2.4.1	
5.2.4.2	Level B	5.2.4.2	
5.2.4.3	Level C	5.2.4.3	
5.3	Marking	5.3	
5.4	General	5.4	
5.4.1	Exterior Containers	5.4.1	
5.4.2	Air Force Requirements	5.4.2	

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revised
6	Notes	6	
6.1	Ordering Data	6.1	
6.1.1	For Transformer and Inductors Covered by Coordinated Specification Sheets	6.1.1	x
6.1.2	For Transformers and Inductors Not Covered by Specification Sheets	6.1.2	X
6.2	Qualification	6.2	
6.3	First Article Inspection	6.3	
6.4	Assignment of Type Designation	6.4	X
6.5	Envelope and Mounting Dimension	6.5	X
6.6	Dielectric Withstanding Voltage	6.6	X
6.7	Induced Voltage Test for Inductors	6.7	
6.8	Magnetic Shielding	6.8	
6.9	Overload and Life Tests	6.9	X
6.10	Notes for Airborne Application	6.10	
6.10.1	Laminated Phenolics	6.10.1	
6.10.2	Transformer and Inductor Sizes	6.10.2	
6.11	Ambient Temperature Increase	6.12	
6.12	Test Circuits for Electrical Characteristics	6.13	
6.13	Reduction of Dielectric - Withstanding - Voltage Test	6.14	
6.14	Notes Regarding General Applications for Equipment Designers	6.15	
6.14.1	Specification Sheet Transformers and Inductors	6.15.1	
6.14.2	Temperature	6.15.3	
6.14.2.1	Maximum Operating Temperature	6.15.3.1	
6.14.2.2	Temperature Rise	6.15.3.2	
6.14.2.3	Ambient Temperature	6.15.3.3	
6.14.3	Envelope and Mounting Dimensions	6.15.4	
6.14.3.1	Overspecified Characteristics Which Effect Size	6.15.4.1	
6.14.4	Working Voltage	6.15.6	
6.14.5	Overload	6.15.7	X
6.14.6	Altitude Rating	6.15.8	

TABLE 8 (Continued)

Paragraph	Title	MIL-T-27 Reference	Revision
6.14.7	Marking	6.15.9	
6.14.8	Environmental Characteristics	6.15.10	
6.14.9	Electrical Characteristics	6.15.11	
6.14.9.1	General	6.15.11.1	
6.14.9.2	Power Transformer	6.15.11.2	X
6.14.9.3	Inductors	6.15.11.3	
6.14.9.4	Saturating Core Power Transformers	6.15.11.5	
6.14.10	Resistance to Solvents	6.15.12	
6.14.11	Seal	6.15.13	
6.15	Center-Tapped Secondary	6.16	X
6.15.1	Center-Tapped Secondary Supplying Unrectified Loads	6.16.1	
6.15.2	Center-Tapped Secondary Supplying Rectified Loads	6.16.2	
6.16	Dielectric Withstanding Voltage	6.18	
6.17	International Standardization Agreement	6.19	
	APPENDIX		
10	Scope	10	
10.1	Details	10.1	
20	Submission	20	
20.1	Qualification of Transformer and Inductor Based on Complete Testing	20.1	
20.1.1	Identification Data Required	20.1.1	
20.1.2	Sample	20.1.2	X
20.2	Qualification of Transformers and Inductors Based on Similarity	20.2	
20.2.1	Similar Transformers and Inductors	20.2.1	
20.2.2	Identification Data Required	20.2.2	
20.2.3	Sample	20.2.3	X

SECTION IV

PARTIAL DISCHARGE TEST SET

Electrical insulation for airborne high voltage equipment must be free of cracks and voids. Void-free insulation used for high voltage equipment will withstand well over 500 volts per mil for 60 seconds. Voids or cracks within the same insulation will have partial discharges across the gas-filled voids at approximately 350 volts/mil. These partial discharges can be detected with suitable detection equipment. Partial discharges may be seen (in a dark room when corona is on the surface), heard (if the ambient noise is low enough), and indicated by electrical measuring instruments including oscilloscope displays. Partial discharges in insulation systems cause momentary changes of potential and consequently current pulses. These pulses superimpose an electrical and/or mechanical signal on the test article which may be detected at the terminals or area of impact (mechanical) under test. The detection and measurement of signals by electronic means has been found to be the most practical method.

A partial discharge test set was assembled, calibrated, and tested for making partial discharge measurements by electrical means on a high voltage cable assembly and a high voltage capacitor. Methods of applying voltage stress, the use of the sine wave ac voltage and steady-state dc voltage, the limitations of voltage stresses encountered, and the limits of the partial discharge pulse energy acceptable are included. Calibration procedures and test conditions and requirements are also included.

4.1 Terminology.

4.1.1 Apparent Discharge Magnitude. The charge transfer measured at the terminals of a sample caused by a partial discharge pulse in a sample.

4.1.2 Applied Voltage. Voltage which is applied across insulation. Applied voltage may be between conductors or from conductor(s) to ground (case).

4.1.3 Continuous Corona (Partial Discharges) Corona (partial discharges) which recur at regular intervals, for example, on approximately every cycle of an applied alternating voltage or at least once per minute for an applied direct voltage.

4.1.4 Corona. A type of partial discharge wherein the electrical discharge is limited to the region immediately surrounding the electrode (or conductor).

4.1.5 Partial Discharge. A type of localized discharge resulting from transient gaseous ionization in an insulation system when the electric field strength exceeds a critical value. The ionization is localized over only a portion of the distance between the electrodes of the system and is accompanied by luminosity (which may, or may not, be detectable), radio frequency noise, and audio noise.

4.1.6 Corona Extinction Voltage (CEV). The highest voltage at which partial discharge (or corona) no longer exceeds a specified intensity as the applied voltage is gradually decreased from above the corona inception value. Where the applied voltage is alternating, the CEV is expressed at $1/\sqrt{2}$ of the peak voltage.

4.1.7 Corona Inception Voltage (CIV). The lowest voltage at which continuous partial discharge (or corona) exceeding a specified intensity is observed as applied voltage is gradually increased. Where the applied voltage is alternating, the CIV is expressed as $1/\sqrt{2}$ of the peak voltage.

4.1.8 Corona Pulse. A voltage or current pulse which occurs at some designated location in a circuit as a result of a partial discharge (corona).

4.1.9 Ionization. Any process producing positive or negative ions, or electrons, from neutral molecules or atoms. The process definition should not be used to denote partial discharges.

4.1.10 Peak Working Voltage (PWV). The maximum instantaneous voltage that may appear under normal rated operation across the insulation being considered. This insulation may be between conductors and ground.

4.1.11 Terminal Corona Charge (Q_t). A charge supplied to the terminals of the insulation system under test, to compensate for the effect of a partial discharge (corona) pulse on the terminal voltage. It is equal to the product of the capacitance of the insulation system and the terminal corona-pulse voltage, that is:

$$Q_t = C_t V_t$$

where Q_t is the terminal charge in coulombs; C_t is the capacitance of the specimen insulating system in farads; and V_t is the peak value of the partial discharge (corona) - pulse voltage appearing across C_t.

4.1.12 Terminal Partial Discharge (Corona)-Pulse Voltage (V_t). The pulse voltage resulting from a partial discharge (corona) represented as a voltage source suddenly applied in series with the capacitance of the insulation system under test, appearing at the terminals of the system under open circuit conditions.

4.1.13 Partial Discharge (Corona) Rate. The average number of partial discharge (corona) pulses per second as determined by an electronic counter set to count all pulses above a preset partial discharge pulse voltage threshold level.

4.2 Background.

4.2.1 Configuration and Frequency. High power electrical and electronic equipment and devices may include all the insulation and electrode (conductor) configurations and arrangements discussed in practical and theoretical treatises. In addition, a large number of devices with special circuit characteristics and with electrical stress on insulation may cover the entire range of frequencies from dc through microwave and all combinations of these frequencies. The partial discharge pulse itself also has a wide frequency spectrum, a portion of which may fall in the range of the operating frequency. This procedure will be limited to detection and measurements with a sine wave applied voltage ranging in frequency from zero at approximately 400 Hz. The detection and measurements of partial discharges at frequencies greater than 400 HZ or with components energized with nonsinusoidal wave shape require special detection equipment.

4.2.2 Circuit Duplication. The duplication of the exact voltage stresses which occur in service, including frequencies and transients, will result in the most accurate partial discharge measurements. However, insistence on exact conditions may be impractical. The fundamental conditions for acceptable tests are based on these limitations.

4.2.3 <u>Partial Discharges</u>. The partial discharge is a function of the peak voltage, provided the voltage is applied long enough for ionization to take place. Partial discharge measurements may be performed at any frequency under 400 Hz; they need not be made at operating frequency.

4.2.4 <u>Void</u>. Partial discharges across voids in solid insulation transfer some of the voltage stress to the solid insulation, thus reducing the stress on the void. This removes the condition necessary for additional discharges until some of the charge dissipates or until the applied voltage changes enough to reestablish the stress required for the discharge.

4.2.5 <u>Direct Current</u>. When the applied voltage is dc, continuous partial discharges (recurring pulses) usually requires a higher voltage than when the stress is ac. The overvoltage necessary to establish continuous discharges with dc applied will depend largely on the resistance of the insulation through which the charge must dissipate to reestablish the stress. This suggests that in apparatus where dc stress alone is characteristic, the partial discharges should be measured with dc voltage applied.

4.2.6 <u>AC and DC Combinations</u>. When the voltage stress is combined dc and ac, continuous partial discharges will be due to the sum of the dc plus the peak ac voltage and, therefore, will occur as if due to the ac voltage. This suggests that in some articles where combined dc and ac stress is applied, measurements may be made with ac as the test voltage provided circuit parts are not damaged by inverse polarity applications.

4.2.7 <u>Rate of Rise</u>. Partial discharge pulse voltage has sufficient rate of rise so that its initial distribution throughout the circuit is controlled by the circuit capacitances.

4.2.8 <u>Circuit Response</u>. The response of the circuit, which includes the insulation system, to frequencies and frequency combinations (wave shape) complicates the partial discharge tests. Square waves, pulses, rapid switching, or high frequencies will produce stress patterns. The application of voltage at frequencies below 400 Hz may not produce the equivalent voltage distribution necessary for accurate evaluation.

When suitable equipment is available, some reassurance may be gained by comparing, on a sampling basis, measurements made under operating conditions with measurements made with sine wave applied voltage at frequencies below 400 Hz.

4.2.9 Signal-to-Noise Ratio. A minimum signal-to-noise ratio of 2 to 1 should be established by reducing all noise interference, regardless of origin, to less than one half of the amplitude of the minimum partial discharge level to be detected.

4.2.10 Test Equipment. When test equipment incorporating discrimination devices is used, the equipment must be capable of discriminating between the minimum level specified for partial discharges in the unit under test and the particular interference present in the test system.

4.3 Partial Discharge Test Set. The equipment required for quantitative partial discharge measurements consists of: a test voltage supply, partial discharge detector, a multichannel analyzer, and associated control metering.

4.3.1 Test Voltage Supply. The test voltage supply shall have variable voltage from 0 to 150 kilovolts. When ac voltage is used, there shall be less than 5 percent overall distortion when supplying the test load. Usually it will be necessary to provide noise filtering. When dc test voltage is used, it shall have less than 5 percent peak-to-peak ripple.

4.3.2 Partial Discharge Detector. The partial discharge test equipment includes: a Detector, a Power Separation Filter, and a Calibration Signal Coupler. Accessory equipment includes a Voltmeter, an Isolator Buffer, a DC Noise Filter, and a Grounding Wand. A system schematic diagram for the facility is shown in Figure 2.

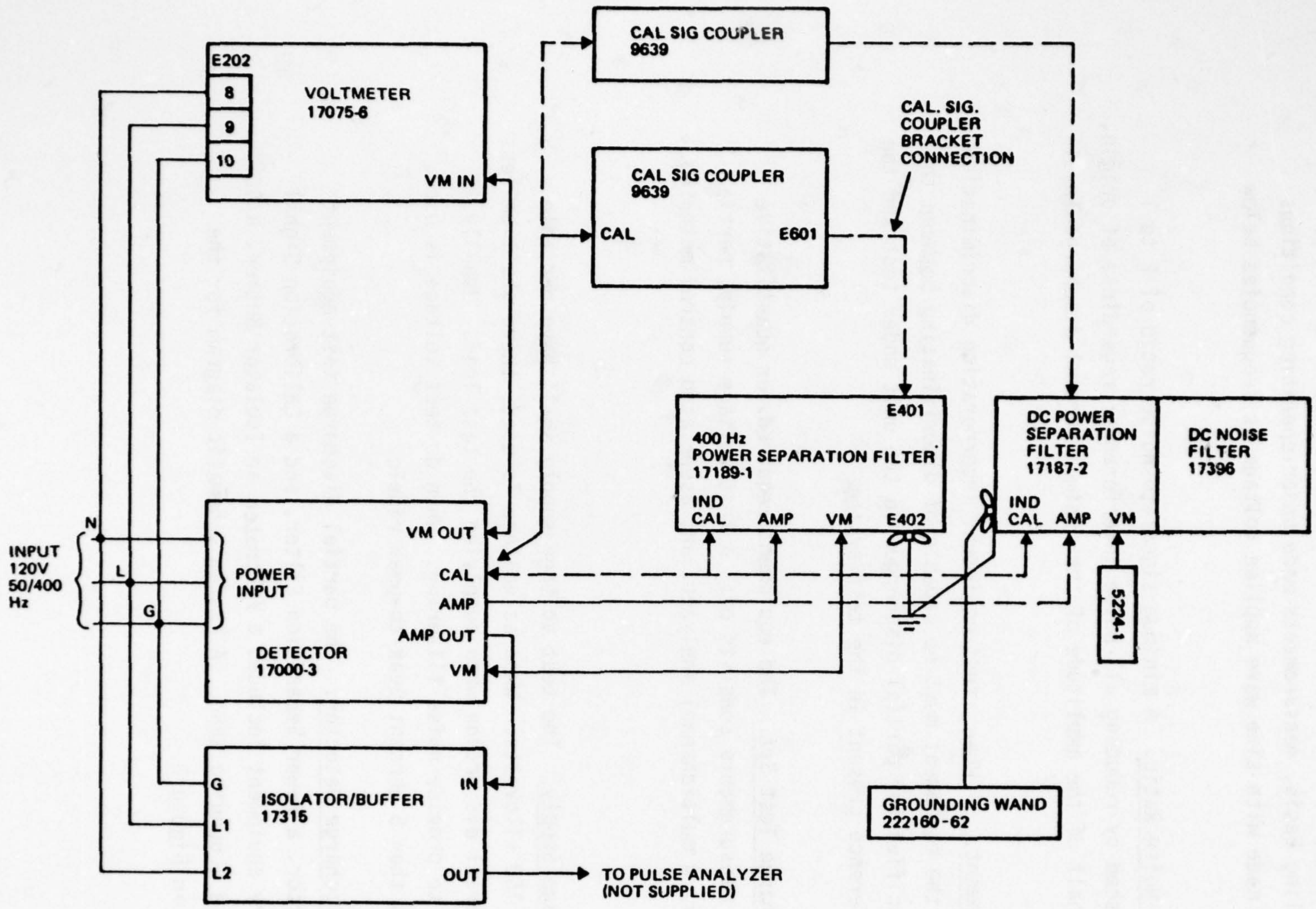


Figure 2: System Schematic

a) Power Separation Filter. The Power Separation Filter is rated 150 kv, dc, 2000 pico-farad (pF). This part isolates the detector from the test voltage. The capacitance value is selected in relation to other circuit components to realize the desired circuit sensitivity. In general, the high capacitance value improves the circuit sensitivity. A value of 2000 pF is considered satisfactory.

b) Detector. The Detector includes a coupling impedance, signal amplifier, and an oscilloscope display. The coupling impedance presents the partial discharge pulses to the input of the pulse amplifier through a capacitive coupling network.

The amplifier amplifies the low-level partial discharge pulses for display on the readout equipment. The band-pass characteristics are selected to provide maximum attenuation of the test voltage frequency and its harmonics as well as other unwanted signals.

The oscilloscope (CRO) displays signals from the amplifier. Other readout devices such as peak reading voltmeter, graphic recorder, pulse height analyzer, etc. may be connected via the buffer/isolator. The CRO is best suited for detecting individual partial discharge pulses and their phase occurrence with respect to the test voltage. The CRO is the primary readout method,with the Multi-channel Pulse Height Analyzer operating in conjunction when more data is required.

c) Calibration Signal Coupler. The Calibration Signal Coupler is used to inject a calibration signal into the detection system at the high-voltage terminal of the power separation filter. This signal produces a response in the detection equipment that approximates a pulse response in magnitude. The pulse has a rise-time no greater than 0.1 microsecond and a decay to half peak of greater than 1 millisecond. Provisions are made for determining the crest value of the output pulse to an accuracy of at least $\pm$ 3 percent.

d) Kilovoltmeter. The kilovoltmeter is used to measure the ac test voltage applied to the test specimen. The meter circuitry is peak voltage responding, calibrated in rms of a sine wave. A voltmeter selector switch is used to change the range corresponding to 100, 50, 20, and 10 percent of the test set voltage rating, i.e., 150, 75, 30, 15 kilovolts.

e) Isolator/Buffer. The Isolator/Buffer is an interface unit between the partial discharge detector amplifier and the Multichannel Pulse Height Analyzer.

f) DC Noise Filter. The DC Noise Filter is an in-line filter between the dc test power supply and the test article/power separation filter. The filter attenuates electrical signals and transients generated in the high voltage test power supply.

g) Grounding Wand. The discharge stick or Grounding Wand is an extension to the system ground. It is used to safely discharge **the test power supply, the test article, and the high voltage separation filter.**

4.3.3 Multichannel Analyzer. The ND 60 Microprocessor Multichannel Analyzer (MCA) system includes a built-in charge sensitive preamplifier and amplifier ideally suited for spectral data acquisition from a pulse-detecting instrument such as a partial discharge detector. A built-in- analog-to-digital converter is designed for high resolution processing of amplitude modulated signals of the type encountered when measuring fast, random phenomena. The data acquisition efficiency is enhanced by a 50 megaHertz digitizing rate and the conversion gain is selectable in increments of 512, 1024, or 2048 channels, full scale.

The built-in cathode-ray oscilloscope displays both spectral and alphanumeric data at a fast, flicker-free, 100 kHz rate.

A controlled microprocessor is fully compatible with the 8080A microprocessor. The memory contains 2048 data storage channels with $2^{20}-1$, i.e., 10,048,575 counts per channel which is ample for the high count rates anticipated by extremely noisy test articles.

The pulse height analyzer (PHA) is used where pulse amplitude is the measurement criterion. The PHA can be automatically terminated by a preset clock, or by real time, or by a preset count total in the channels between markers. Preset time is selectable from one to 9 million seconds. Likewise the preset counts are selectable from one to nine million counts in one-count increments.

4.3.4 Control Metering. Control metering must have an accuracy of $\pm$ 3 percent. Metering for the ac test voltage source shall be peak sensitive calibrated with sine wave rms so that the test voltage may be specified in rms units. When the test voltage is induced, the measured value should be the actual test voltage (the use of suitable potential transformers is accepted).

4.3.5 Partial Discharge Test Equipment. The partial discharge test equipment has all the items listed in Table 9. The equipment was purchased from the James G. Biddle Company of Plymouth Meeting, Pennsylvania. This equipment is referred to by James G. Biddle as a Partial Discharge (corona) Test Equipment, Catalog number 661028-01. The test equipment consists of the subassemblies listed in Table 9 and shown in Figure 2.

TABLE 9. PARTIAL DISCHARGE TEST EQUIPMENT

	Subassembly	Manufacturer	Model
A.	Detector	James G. Biddle	17000-3
B.	Power Separation Filter	James G. Biddle	17182-3 + 17189-1
C.	Calibration Signal Coupler	James G. Biddle	9639
D.	Kilovoltmeter (Accessory)	James G. Biddle	17075-6
E.	Isolator Buffer (Accessory)	James G. Biddle	17315
F.	D. C. Noise Filter (Accessory)	James G. Biddle	17396
G.	Grounding Wand (Accessory)	James G. Biddle	222160-62

4.3.6 Microprocessor MCA. The microprocessor multichannel analyzer was purchased from Nuclear Data, Inc., Schaumburg, Illinois. This equipment is referred to as catalog number ND 60. All circuits and keyboards are mounted in a single chassis.

4.4 **Calibration.**

4.4.1 Test Circuit. A calibrated master calibrator is used to verify the sensitivity of the Partial Discharge Detector and the Multichannel Analyzer as a system. The system sensitivity is influenced by the specimen capacitance, stray capacitance, and the amplifier gain. Since these factors may vary from specimen to specimen, both instruments must be calibrated as part of the test procedure, and whenever any of the influencing factors are significantly changed. The amplifier gain should not be changed between calibration and test.

4.4.2 Specimen. Normally, calibration is performed with the specimen de-energized either before or after applying test voltage. When it is desired to make signal magnitude measurements during testing, the calibration equipment may be switched in, but the calibration measurements must be verified at zero voltage.

4.4.3 Partial Discharge Test Set. To calibrate the partial discharge test set, a pulse of known crest voltage from the calibrating pulse generator is introduced into the circuit at the terminals where the test specimen is connected, i.e., the point at which the partial discharge pulse is to be detected. With the amplifier gain selected for observation of the actual partial discharges, the maximum deflection caused by the calibrating pulse is observed. From this measurement and from the constants of the circuit, the deflection sensitivity of the readout device to the partial discharge pulses is calculated. Calibration procedures for the master calibrator and the test set are detailed in paragraphs 4.5 and 4.6.

4.4.4 Direct Calibration (Sample Connected). In this calibration mode, the Calibration Signal Coupler is connected directly to the top of the Power Separation Filter and the calibration cable from the Partial Discharge Detector (PDD) is connected to the BNC connector on the coupler. The sample to be tested is also connected in parallel with the Power Separation Filter (see Fig. 3). Pulses of a given magnitude (e.g., 10 picocoulombs) are applied by switching the calibrator on the PDD to "DIR CAL" and setting the Charge PC and Charge Multiplier for 10 PC. The height of the pulse is observed on the scope of the PDD (e.g., 5 cm). The signal coupler is then removed. The set is calibrated, i.e., 5 cm high pulses correspond to 10 PC. To display a calibration signal during high voltage operation, the indirect calibration mode must be used as described below.

4.4.5 Indirect Calibration. After removing the Calibration Signal Coupler from the Power Separation Filter, the calibration cable from the PDD is connected to the IND CAL connector (BNC) at the base of the Power Separation Filter (see Fig. 4). Again, the 10 PC pulses are applied via the Calibrator on the PDD; however, this time the Calibrator must be switched to "IND CAL." The height of the pulses is noted on the scope of the PDD. The "IND CAL ADJ" control is then used to adjust the pulse height to 5 cm as obtained with the DIRECT CALIBRATION procedure. Now the indirect mode can be used to display pulses of a certain PC level directly on the scope while high voltage is applied to the Power Separation Filter and the sample.

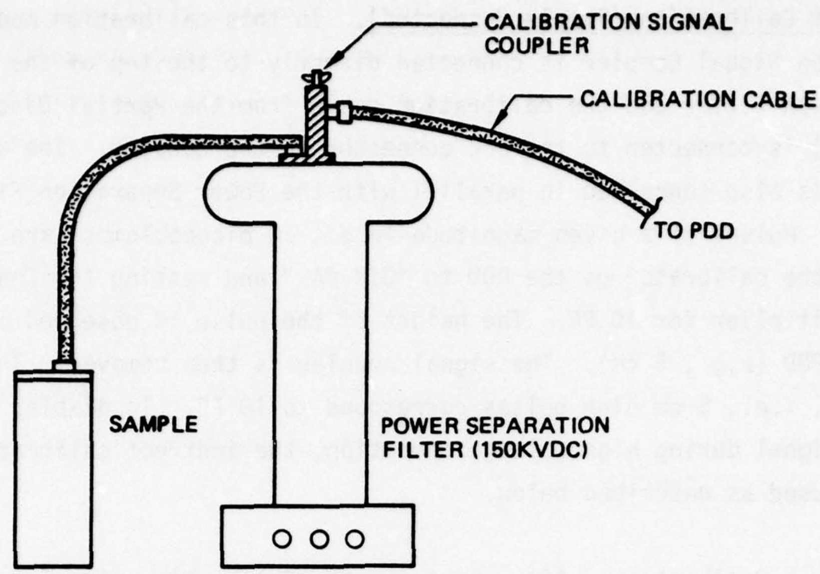


Figure 3: Direct Calibration

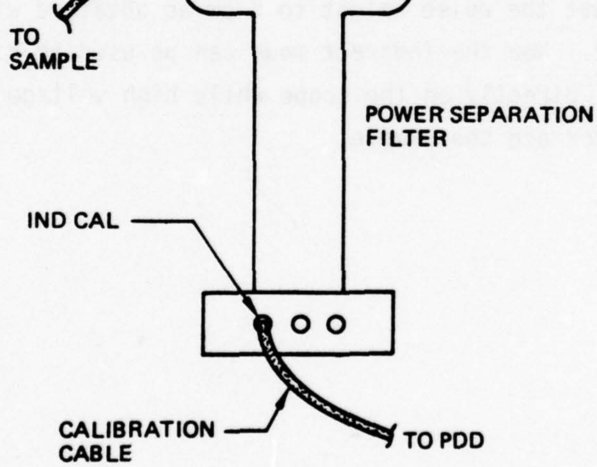


Figure 4: Indirect Calibration

4.4.6 Calibration Circuits. To simplify the calculation of detection sensitivity, the terminal partial discharge pulse voltage and the calibrating pulse voltage are both considered as step functions. The initial division of voltage throughout the circuit is considered to be determined by the circuit capacitance. Refer to ASTM D1868 and ASTM D3382 for acceptable calibration circuits and their respective sensitivity equations.

4.4.7 Multichannel Analyzer. To calibrate the Multichannel Analyzer, pulses of known magnitude and number per second are introduced into the circuit at the terminals normally connected to the partial discharge test set buffer/isolator output. With the pulse channels and time selected, the number of pulses are counted for each analyzer register.

4.5 Detector Calibration Procedure. This procedure describes the calibration and certification of the James G. Biddle partial discharge test system No. 661028-10.

4.5.1 Specifications/Tolerances. Tolerances and limits stated in this procedure do not necessarily reflect manufacturers specifications but rather reflect the tolerances and limits needed for use in applications.

Characteristics	Certification Tolerances	Calibration Limits
1- Voltage	± 3% of full scale 150kV 400 Hz	± 2.5% of full scale 0-150 0-150 kV 400 Hz
2- Charge (pico-coulombs)	± 6.0% at 1" deflection for pulse range selected; lowest range 0.1 pico-coulomb.	± 5% at 1" deflection for pulse range selected; lowest range 0.1 pico-coulomb.

4.5.2 Calibration Equipment Required. The "Minimum Use Specifications" list the critical requirements of the calibration standards and equipment necessary for the calibration of the Test System.

Item	Minimum Use Specifications	Recommended Equipment
Square Wave Generator	Freq.: 300 to 900 Hz Symmetry: Variable 25-75% Polarity: Pos. or neg. Rise Time: 25 µS Output Level: 15 mV to 1V	Hewlett-Packard Model 3310A
Oscilloscope	Deflection Factor: 5mV/cm Rise Time: 20 nS max. Amplitude Calibrator: 1mV to IV Accuracy: ± 3%	Tektronix-545B with a Type 1A1 plug-in
Capacitors	Value: 10, 100, 1000pF Accuracy: ±1% of value stated, 3 terminal Voltage Rating: 20V	General Radio 1403G(10) 1403D(100) 1403A(1000)
Electrostatic Voltmeters (2)	400 Hz, ± 1% of f.s., Range 0-1 00 kV, and 400 Hz±1% of f.s., Ranges 0-30/50 kV	Sensitive Research Model ESH, 0-100 kV f.s., and Sensitive Research Model ESH; Ranges 0-30/50 kV full scale)

4.5.3 Partial Discharge Internal Calibrator Calibration Procedure.

a) Connect calibration equipment as shown below in Figure 5 and described in Step c).

b) Ensure that a low resistance earth ground is connected properly to the chassis of the partial discharge test set.

c) Connect the 1000 pF standard capacitor output connector to the separation filter by means of a coax cable. The connection to the separation filter shall be by two leads, one to ground, the other to the high voltage terminals.

d) Supply line power to the external scope and square wave generator and set the square wave generator controls to supply 20 pc @ 120 Hz to the standard capacitor. Allow a 5 minute warmup.

e) Reduce the square wave generator output to minimum.

f) Center the partial discharge detector scope in the straight line configuration.

g) Set the partial discharge test system calibrator for 90 pC.

h) Adjust the partial discharge detector gain for a 1 cm deflection on the scope.

i) Switch the partial discharge Calibrator Off.

j) Increase the square wave generator output to produce a 20 pC (equal to 20 mV.) deflection on the oscilloscope. Signals 1 cm high should appear on the partial discharge detector scope.

k) Adjust partial discharge detector gain for 1 cm pulse height from the square wave generator.

l) Compare the value of the pulse discharge internal calibration pulse with the value of the calibration circuit. Repeat 5.5.2 and 5.5.5 for settings of 1000/750/500/50/10/1 and 0, 1 picocoulombs. Do not turn off the partial discharge detector or calibration circuit between readings. The partial discharge detector gain must be adjusted to obtain pulse height greater than 1cm.

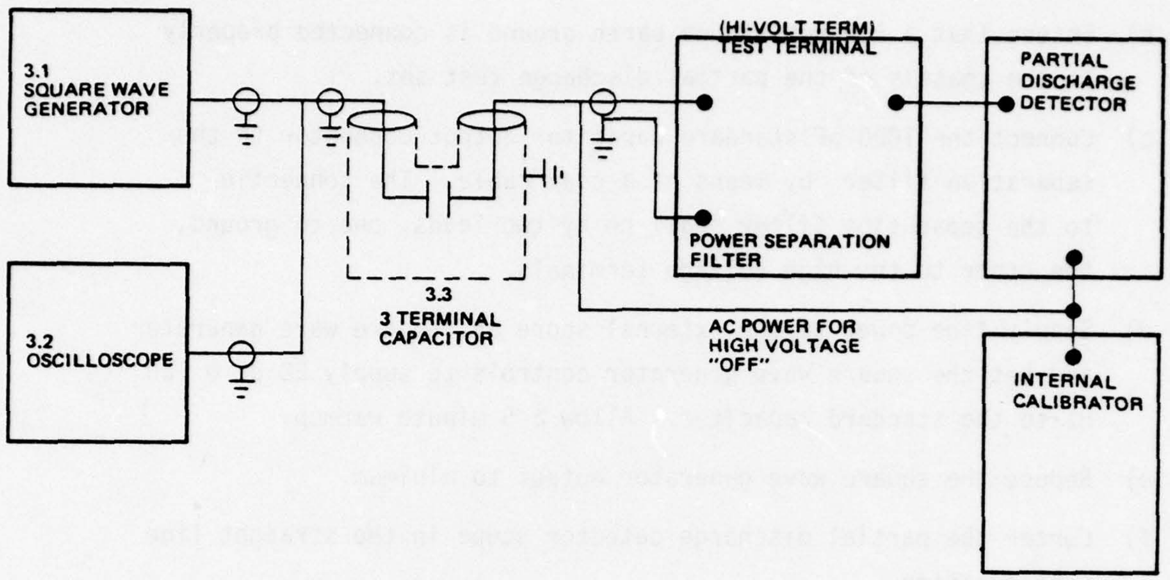


Figure 5: Calibration Circuit for the Partial Discharge Detector Internal Calibrator

m) Disconnect the square wave generator, the external oscilloscope, the 3 terminal capacitor and all test cables from the partial discharge test set. Turn power switches on pulse calibrator and the partial discharge detector to "off" position. This concludes the first half of the calibration test.

4.5.4 Kilovoltmeter Calibration.

a) Connect the calibration equipment as shown in Figure 6 for calibration of the power panel kilovoltmeter.

b) Place the electrostatic voltmeter on top of the partial discharge test set and level and zero it. Connect the inner conductor of a coax cable to the test electrode. Leave approximately a 6" length of coax dielectric between the conductor and the shield which is folded back on itself and secured close to the coax sheath. Connect the center conductor of the coax cable to the undergrounded test set terminal. Connect the other end inner conductor to the electrostatic volt meter the same way with the shield folded back as above. Connect the ground terminal of the electrostatic voltmeter to the power ground. Keep large clearances about 3 ft. for non-plane structures which are at ground potential between all exposed high voltage parts and any ground structure. Zero the panel voltmeter, if required.

c) Turn the power switch to "ON" and with the panel voltmeter range set on 150kV, adjust the variable control until 100 kV is reached on the panel voltmeter. Read the true voltage on the electrostatic voltmeter. Calibrate the panel meter at each cardinal division line, i.e. 100/75/50/25 kV on the highest range, reading the true voltage on the most suitable electrostatic voltmeter. Adjust the panel voltmeter trimming resistor, if necessary, to meet the calibration limits. Slight tapping is permitted.

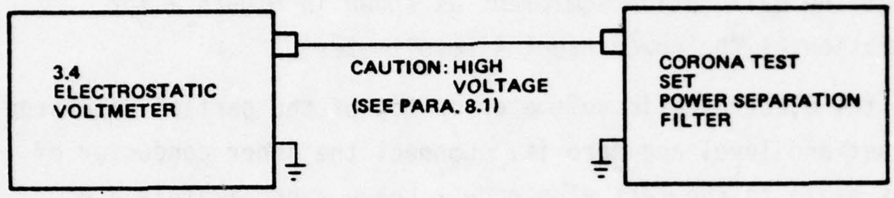


Figure 6: Calibration Circuit for the HV Voltometer

d) Repeat d) for the other kV ranges. Failure to meet calibration limits shall require removal and repair of the panel voltmeter if the trimming resistor will not bring the indications within the specified tolerance or if there is excessive friction or roll.

4.5.5 Sealing and Labeling. Place a Type II Test System label, on the lowest, or power panel near the equipment nameplate. Enter the document number of the calibration procedure on the Type II Test System label.

4.5.6 Special Instructions. Voltages which are lethal are encountered during the calibration of the panel voltmeter. Extreme caution should be exercised when this portion of the procedure is being used. Make sure all equipment grounds are operable and that clearances in air between high voltage parts which can be energized as high as 150 kV to ground are at least 6". Turn power switch "OFF" when changing electrostatic voltmeter ranges.

The calibration of the partial discharge detector and calibrator does not require the high voltage section to be energized. Make certain the main power switch on the high voltage power supply is "off" except when calibrating the panel voltmeter.

Persons calibrating this equipment shall be familiar with Industrial Hazards Bulletins S-13, S-15 and S-16.

4.5.7 Partial Discharge Internal Calibrator. Calibration procedure using the master calibrator.

a) Pulse calibration

b) Connect the master calibrator as shown in Figure 7 for the calibration of the internal calibrator.

c) Energize the master calibrator and allow approximately 5 minutes for warmup.

d) Set the master calibrator output for 20 pC.

e) Set the internal calibrator for 20 pC. Use the higher pulse for calibration and recording.

f) Both signal calibrator signals will be displayed on the oscilloscope. They should be the same height. **Record differences.**

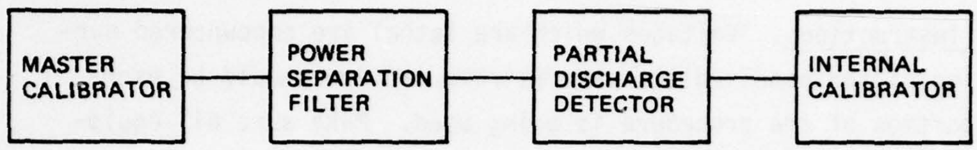


Figure 7: Calibration Circuit for the Partial Discharge Detector Using the Master Calibrator

4.5.8 Certification Criteria. The minimum requirements for certification are as follows:

NOTE: Additional testing may be requested by the person certifying when there is evidence of conditions which may compromise the certified performance of the system.

a) Verify that the Test System is properly identified as a TYPE II TEST SYSTEM and ensure that the calibration document number is entered on the certification label.

Verify that the Test System's configuration is as stated in Section 1.0 of this procedure.

b) Verify that the proper calibration procedure is present on site for the test system.

c) Verify that the data requirements of this procedure have been accomplished.

d) Verify that the past historical data is being maintained.

e) Verify that paragraph 4.5.3 or 4.5.7 for the pulse calibration and paragraph 4.5.4 for the panel voltmeter have been properly followed and a valid data sheet with all required data is on hand, by actually witnessing the tests.

NOTE: WHEN ALL THE CONDITIONS AND REQUIREMENTS OF THIS PARAGRAPH OF THIS PROCEDURE ARE MET, THE TEST SYSTEM IS QUALIFIED FOR CERTIFICATION.

4.5.9 Certification, Records, Sealing, Labeling and Stamping.

a) Instructions for the Calibration Transaction Card. The person certifying will be responsible for the following information recorded on the Transaction Card, Table 10.

TABLE 10. CALIBRATION TRANSACTION CARD

Item Nomenclature	Data
1. Manufacturer	
2. Model	
3. Name	
4. Procedure Number	
5. Submitting Orgn.	The organization number of the system using organization.
6. Rec. Date	Manufacturing production date on which calibration was started.
7. Owner	The owner code.
8. Property Number	The end property number of the Test System.
9. Dash No.	The dash number of the property number.
10. Acc. Cert.--Rec. Status	By observing the calibration data record, determine if the Test System was IN or OUT of tolerance prior to calibration. Or if the Test System needed repair prior to calibration and circle the proper block.
11. Cal. Time	The actual time required for certification.
12. Date Cal.	Manufacturing calendar date of the day certified.
13. Next due date	The Manufacturing calendar date when the Test System will be due for recertification.
14. Calibration Test Points	By observing the calibration data record, determine which, if any of the EDP T/P were out of tolerance. If the measurement was out of tolerance "high"-, the "+" is encircled. If the measurement was "low", the "-" is encircled.
15. Qualification	The inspection stamp of the person certifying.

b) Seal the high voltage module, pulse calibrator and the partial discharge detector of the Test System with stamped and dated "Certification Void-if-Broken" seals to the main frame. Stamp and date. Seal the panel meter zero correctors adjustments with Certification Void-if-Broken seals. Stamp and date.

c) Apply an inspection stamp "bug" to the calibration data recording record and date.

d) Apply an ACCURACY CERTIFIED tab to the TYPE II TEST SYSTEM identification label on the high voltage module.

e) Complete the label entries as follows:

1) Put today's date (calendar date) in the "ISSUE DATE" space.

2) Calculate the due date by adding the AC-CY cycle referred to in Section 2.0 to the entry in the "ISSUE DATE" space and convert the answer to a standard.

3) **Note calendar date and enter in "NOT VALID AFTER"** space.

4) Have the calibrating technician stamp the "TECH" block.

5) Stamp the "ISSUED BY" block.

6) The certifying agent will forward the completed hard copy of the Calibration Transaction Card to the Coordinator.

4.5.10 Special Instructions. Calibration tests to be performed if seals are broken or repairs done on the Test System: All sections of the certification procedure will be performed.

SUBASSEMBLY	CALIBRATION PROCEDURE PARAGRAPH NUMBER

Calibration shall include the data points shown in Table 11, as a minimum.

TABLE 11. CALIBRATION DATA

Parameter	Range	EDP T/P
Pulse	1000 pF	1
"	750 "	2
"	500 "	3
"	250 "	4
"	50 "	5
"	10 "	6
"	1 "	7
Voltage	100 kV*	8
"	75 "	9
"	50 "	10
"	25 "	11

*F.S. = 150 kV

4.5.11 <u>Internal Calibrator Calibration Data</u>. The internal calibrator was calibrated with a standard calibration circiut using the equipment and circuit shown in Figure 3. The test data is shown in Table 12.

TABLE 12. INTERNAL CALIBRATOR CALIBRATION DATA

Standard Calibration Circuit Figure 3				Biddle Partial Discharge Detector		
Capacitor PF	Voltage MV	Charge PC	Charge Multiplier	Charge PC [1]	Error PC [2]	Gain
1000						
1000	20 MV	10	1	11	+1.0	10
"	50	25	1	26.9	+1.9	10
"	100	50	1	52.0	+2.0	10
"	150	75	1	78.0	+3.0	10
"	200	100	1	104.0	+4.0	1
"	250	125	1	135.0	+10.0	1
"	300	150	1	140.0	-10.0	
"	400	200	1	190.0	-10.0	1
"	500	250	1	244.0	- 6.0	0.1
"	600	300	1	296.0	- 4.0	0.1
"	800	400	1	389.0	11.0	1
"	1000	500	1	485.0	-15.0	1
"	1200	600	1	587.0	-13.0	1
"	1500	750	1	743.0	- 7.0	1
"	2000	1000	1	982.0	-18.0	

[1] The biddle partial discharge detector reads ½ that of the standard calibration circuit.

[2] Compensated for ½ values.

4.5.12 Calibration with Master Calibrator. The internal calibrator was calibrated using the master calibrator and the test curcuit shown in Figure 7. Test results are shown in Table 13.

TABLE 13. INTERNAL CALIBRATOR CALIBRATED WITH MASTER CALIBRATOR

Master Calibrator			Partial Discharge Detector		ND-60	
Charge PC	Charge Multiplier	Output PC	Charge Multiplier	Scope cm	Channel	Counts
2	0.01	0.02	0.01	1.5	37	375
5		0.05		3.0	132	385
7.5		0.075		4.5	202	372
10		0.1		5.75	278	335
1	0.1	0.1	0.1	0.4	--	--
2		0.2		1.0	35	1147
5		0.5		2.7	128-129	1493-1571
7.5		0.75		4.0	201-223	1471-171
10		1.10		5.5	274-305	1690-151
10	1.0	10	1.0	0.4	---	---
20		20		1.0	37	1597
50		50		2.8	130-143	1798-199
75		75		4.25	205-230	1588-190
100		100		5.7	280-327	1639-186
100	1.0	1.50	1.0	.4	6-11	1124-177
200		200		1.1	43-51	1977-226
500		500		3.0	146-166	1900-187
750		750		4.6	220-263	1904-171
1000		1000		6.0	324-359	1756-231

4.6 Master Calibrator Calibration. This procedure describes the calibration of the J. G. Biddle Calibrator, Model No. 17250.

4.6.1 Specifications/Tolerances. Tolerances and limits stated in this procedure do not necessarily reflect manufacturers specifications but rather reflect the tolerances and limits needed for use in applications.

4.6.2 Calibration Equipment Required. The "Minimum Use Specifications" list the critical requirements of the calibration standards and equipment necessary for the calibration of the Master Calibrator.

Item	Minimum Use Specifications	Recommended Equipment
(a) Square Wave Generator	Freq: 60 to 900 Hz Symmetry: Variable 25-75% Polarity: Pos. or neg. Rise Time: 25 μS Output Level: 15 mV to 10V	Hewlett-Packard Model 3310A
(b) Dual-Beam Oscilloscope	Deflection Factor: 1mV/cm Rise Time: 20 nS max. Amplitude Calibrator 1 mV to 1V Accuracy: ±3%	Tektronix-551 with Type D plug-in.
(c) Capacitors	Value: 10, 100, 1000 pF Accuracy: ±1% of value stated, 3 terminal Voltage Rating: 20V	General Radio 1403G (10) 1403D (100) 1403A (1000)

4.6.3 Preliminary Operations.

(a) Connect calibration equipment as shown below in Figure 8 and described in Step (c).

(b) Ensure that a low resistance earth ground is connected properly to the chassis of the master calibrator and test circuit.

(c) Use the 1000 pF standard capacitor calibration checkout.

(d) Supply line power to the external scope and the square wave generator. Set the square wave generator controls to supply 20 millivolts p-p @ approximately 120 Hz.

(e) Adjust the square wave generator frequency such that two or more steady pulses appear on the dual-beam oscilloscope.

(f) Set the master calibrator for 20 pC.

(g) The master calibrator pulses and the calibration circuit pulses will appear on the oscilloscope.

(h) The calibrator pulse height and calibration pulse height should be identical.

(i) Adjust the master calibrator pulse height (detector scope) to the same height as the calibration test circuit pulse height.

(j) Record both pulse heights and indicate master calibrator error.

4.6.4 Sealing and Labeling. Place a Type II Test System label on the lowest, or a power panel near the equipment nameplate. Enter the document number of the calibration procedure on the Type II Test System label.

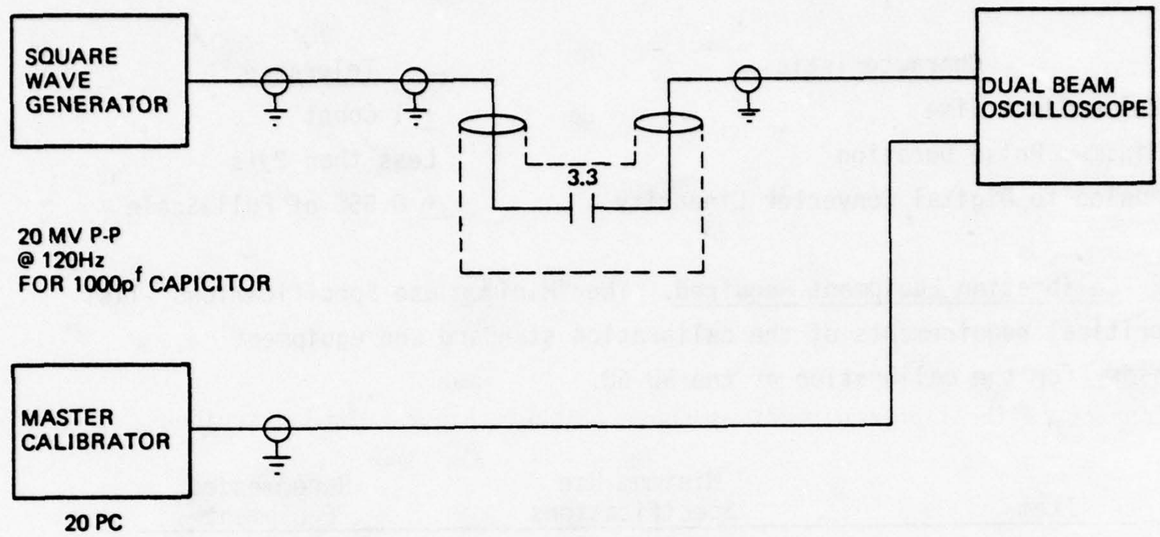


Figure 8: Calibration Circuit for the Master Calibrator

4.7 ND 60 Calibration. This procedure describes the calibration and certification of the Nuclear Data ND 60 Multichannel Analyzer.

4.7.1 Specification/Tolerances. Tolerances and limits stated in this procedure do not necessarily reflect the manufacturer's specification but rather reflect the tolerances and limits needed for use in application.

Characteristic	Tolerance
a. Pulse Clock Time	± 1 Count
b. Minimum Pulse Duration	Less than 2 μs
c. Analog to Digital Converter Linearity	± 0.55% of Full Scale

4.7.2 Calibration Equipment Required. The "Minimum use Specifications" list the critical requirements of the calibration standard and equipment necessary for the calibration of the ND 60.

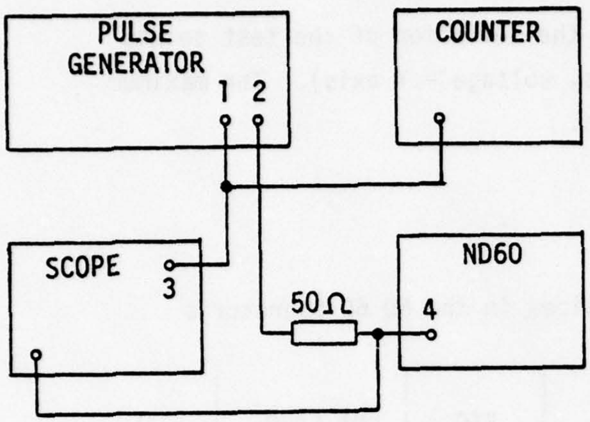
Item	Minimum Use Specifications	Recommended Equipment
a. Direct Voltmeter	Range: 0 to 10V Accuracy: ± (0.002% of RDG + 3 Digits)	Hewlett Packard Model 3455A
b. Oscilloscope	Range: 10mV/cm to 1V/cm	Tektronix Type 545 with Type W Plug In
c. Pulse Generator	Pulse Width 0.1 to 10 μs Pulse Amplitude 50 mV to 10V	Hewlett Packard Model 214A
d. Counter	Range: 1kHz to 500 kHz Resolution: 0.1 Hz at 5kHz	Eldorado Model 1410
e. Direct Voltage Source	0 to 10V	As available

4.7.3 Preliminary Operation. Turn on the ND 60 and set the time of day display for an operational check.

4.7.4 Calibration Procedure.

a. PULSE HEIGHT CLOCK TIME

1. Set up the test equipment as shown:



TERMINAL 1 - TRIGGER OUTPUT
2 - PULSE OUTPUT
3 - TRIGGER INPUT
4 - DIRECT INPUT

2. ND 60 rear panel switch positions: ACQ, DIR, OFF.
3. ND 60 CRT display: PHA PTL, NGR 2,
   PRE 10, 50, 100, 200 (test points)
   GRP 1, CFS 1048576, MLC 1, MRC 512
4. Set the input signal to the ND 60 of 2.0 μs pulse length, 2.0V peak pulse height and 5000 Hz input frequency.
5. Record ETC, CCH, CCO, RNA and the average input frequency on the Data Record for time intervals of 10, 50, 100, and 200 seconds.
6. Calculate the RNA/FREQ and the difference from the indicated ETC. These values should be less than 1 count.

b. MINIMUM PULSE DURATION

1. Use the equipment setup shown in a(1).
2. Set PRE at 1000 and the pulse height to 2.0V, 10 μs width.
3. Turn the ACQUIRE on and set the cursor at the peak channel. Reduce the pulse width until the peak channel decreases by five percent. Record the pulse width on the Data Record. The value should be less than 2.0 μs.

4.7.5 Linearity.

a. Attach a direct voltage source to the PIR input rear terminal. Monitor the level with a digital volt meter.

b. Rear panel switch positions: STROBE, DIR, OFF.

b. **Rear panel switch positions: STROBE, DIR, OFF.**

c. Set the display as follows: NGR 1; PRE 10; GRP 1; MLC 1; MRC 2048.

d. Record the channel number at five equally spaced input voltages over the ADC input range (0 - 8V).

e. Calculate the least square curve fit and the deviation of the test points from the best fit line (channel = X axis, voltage = Y axis). The maximum deviation should be less than 0.004 volts.

4.7.6 Data Record.

a. PULSE HEIGHT CLOCK TIME

This procedure uses the terminology contained in the ND 60 Operator's Instruction Manual.

PRE	CCH	CCO	RNA	FREQ. (Hz)	ETC	RNA/FREQ	Δ
10	106	13636	46526	5002.3	9	9.30	-0.30
50	105	59872	265483	5002.8	53	53.07	-0.07
100	106	147925	539200	5003.4	108	107.77	+0.23
200	106	293329	1086701	5004.0	217	217.17	-0.17

PASS x FAIL ____

b. MINIMUM PULSE DURATION

Value 1.4 PASS X FAIL ____

c. LINEARITY

TEST POINT	AVE. PK. CHANNEL	VOLTAGE	DEVIATION
1	284.00	1.5355	0.0007
2	642.00	2.9728	0.0001
3	1023.77	4.5052	0.0010
4	1423.00	6.1081	-0.0013
5	1803.00	7.6370	0.0014

PASS x FAIL ____

Calibrating Tech/Eng. ____________ Date ________

Certifying Agent ____________ Date ________

4.7.7 Operation and Setup of the ND 60 for Data Acquisition on the Partial Discharge Test Set.

This covers the setup and turn-on procedures of the ND 60, as well as the setup for running a program on the ND 60 to calculate partial discharge energy. This procedure does not replace the information contained in the ND 60 Operator's Instruction Manual, it only is a brief addition to it for the purpose stated above.

a. Turn on and initialization of the ND 60.

1) On Rear Panel

Control	Position
POWER OFF/ON	OFF
ACQ/MCS/STROBE	ACQ
DIR/AMP	DIR
COIN/OFF/ACOIN	OFF

2) Plug AC power cord to AC IN receptacle in back of ND 60, and to 115 VAC 60Hz power source receptacle.

3) On Front Panel

Control	Position
ULD	Full CW
LLD	Full CCW
ZERO	Full CCW
GAIN	Mid range, or 5.0

4) On Rear Panel position the POWER OFF/ON switch to ON, then wait until display illuminates and intensity stabilizes. Adjust intensity and positions as desired.

5) Enter the current line of day by pressing push buttons as follows:

Current hour (1-24) , INIT,
Current minute (1-60) , INIT,
Current second (1-60) , INIT,

The clock should now be operating and showing the correct time on the screen.

b. Setup for ND 60

1) Select pulse height analysis (PHA) preset live time mode. Press & release MODE switch until PHA PTL appears on the screen.

2) Select the add mode.
SET , (+) , INIT

3) Select 4 groups.
SET , GRP , 4 , INIT.

4) Select a preset live time of 1 hr. (3600 sec) or 1 minute (60 sec)
SET , PRST , 3600 , INIT.
(or 60)

5) Select CRP 1 region of interest.
SET , CRSR , 1 , INIT , MARK
SET , CRSR , 512 , INIT , MARK.
On screen GRPI , MLC 1 , MRC 512

6) Select GRP 2 region of interest
VIEW, GRP , 2 , INIT ,
SET, CRSR, 1 , INIT , MARK ,
SET , CRSR , 512 , INIT, MARK
on screen GRP2 , MLC 1 , MRC 512

7) Select groups 3 & 4 regions of interest as in (6.), pressing 3 or 4 as necessary after VIEW, GRP ___

8) Connect data signal cable to DIRECT BNC receptacle on back panel.

c. Partial Discharge Energy
W = 1/2 QV
Steps to test and apply the equation with data on the ND 60.

1) Calibrate scale: (See Note)
   (a) Provide calibrated signals of specified pico coulomb levels.
   (b) Press ACQ INIT
   (c) Adjust cursor to near center of curve of each calibration curve and note picocoulomb level ratio to channel number (CCH).
   (d) For each ith calibration level calculate $N_i = \frac{PC_i}{CCH_i}$
   Let $N = N_i$ ave.

2) Data calculations.

$$Q = N \times \sum_{i=1}^{\infty} \left[CCH_i \times CCO_i\right]$$

where i is an identifier for each level of detected discharge, and N is found in 1.d.

3) Perform Corona Discharge test at a specified voltage (V) and take the data on the ND 60.

NOTE: The LLD control may have to be adjusted to eliminate operation on low level data.

4) A program may be used to take data automatically and to perform the above calculations as shown in d.

d. ND 60 program for Partial Discharge Energy acquisition and calculation.

Program Steps:

1) Select auto sequence entry page.

VIEW AUTO INIT

2) Initialize Memory:

AUTO	ERASE	GRP	1	INIT	
AUTO	ERASE	GRP	2	INIT	
AUTO	ERASE	GRP	3	INIT	
AUTO	ERASE	GRP	4	INIT	

3) Acquire data in Group 1

AUTO	ACQ	GRP	1	INIT	
AUTO	ACQ	WAIT	INIT		

4) Calculate energy from data in Group 1 and display in Group 4.

AUTO	VIEW	GRP	4	INIT	
AUTO	TRFR	(½NV)	GRP	1	INIT

5) Terminate auto sequence.

AUTO HALT.

e. To run Program.

1) Adjust Corona Test Set Detector for the decade level of data desired.

2) Execute the current auto analysis sequence.
   SET AUTO 1 INIT
3) When READY stays on the screen, the program run is complete.
4) The total discharge energy is then the sum of all the CCHi x CCOi in Group 4.

4.7.8 <u>ND 60 Calibration Data</u>. The ND was calibrated using the Biddle detector internal calibrator. The test data is shown in Table 14. A plot of the ND 60 channel number and the in calibrator output in picocoulombs is shown in Figure 10.

4.7.9 <u>ND 60 RBA and RNA Calculations</u>. The Regional Background area (RBA) is calculated as follows:

$$RBA = ((Y_L + Y_R)/2) * (R - L + 1)$$

where: Y_L = Spectral counts in left marker channel

Y_R = Spectral counts in right marker channel

L = Left channel marker number

R = Right channel marker number

RBA = Regional Background area in counts.

The total count from the left to the right channel is calculated as follows:

$$T = \sum_{i=1}^{C} Y_i$$

where: T = The total counts from the left to the right channel

i = Channel index

Y_i = The spectral count in channel i

C = The total number of channels being summed; R - L + 1

L = Left channel marker number

R = Right channel marker number

The Regional Net Area (RNA) is calculated as follows:

RNA = T - RBA

where: T = The total counts from the left to the right marker

RBA = The regional background area in counts

RNA = The regional net area in counts

The diagram on Figure 9 shows the relation among channels, counts, and areas.

4.7.10 Clock. The pulse clock time was tested at 10, 50, 100, 600 and 2000 seconds and was found to be within one count. The minimum pulse width, that resulted in a shift in the peak channel number of five percent was 1.4 microseconds. The linearity was checked in the full, half, and quarter memory modes of operation. The root mean square deviation from least square best fit straight lines were 0.0010, 0.0013, and 0.0032 volts, respectively. The measurement accuracy was $\pm$ 0.002 volts.

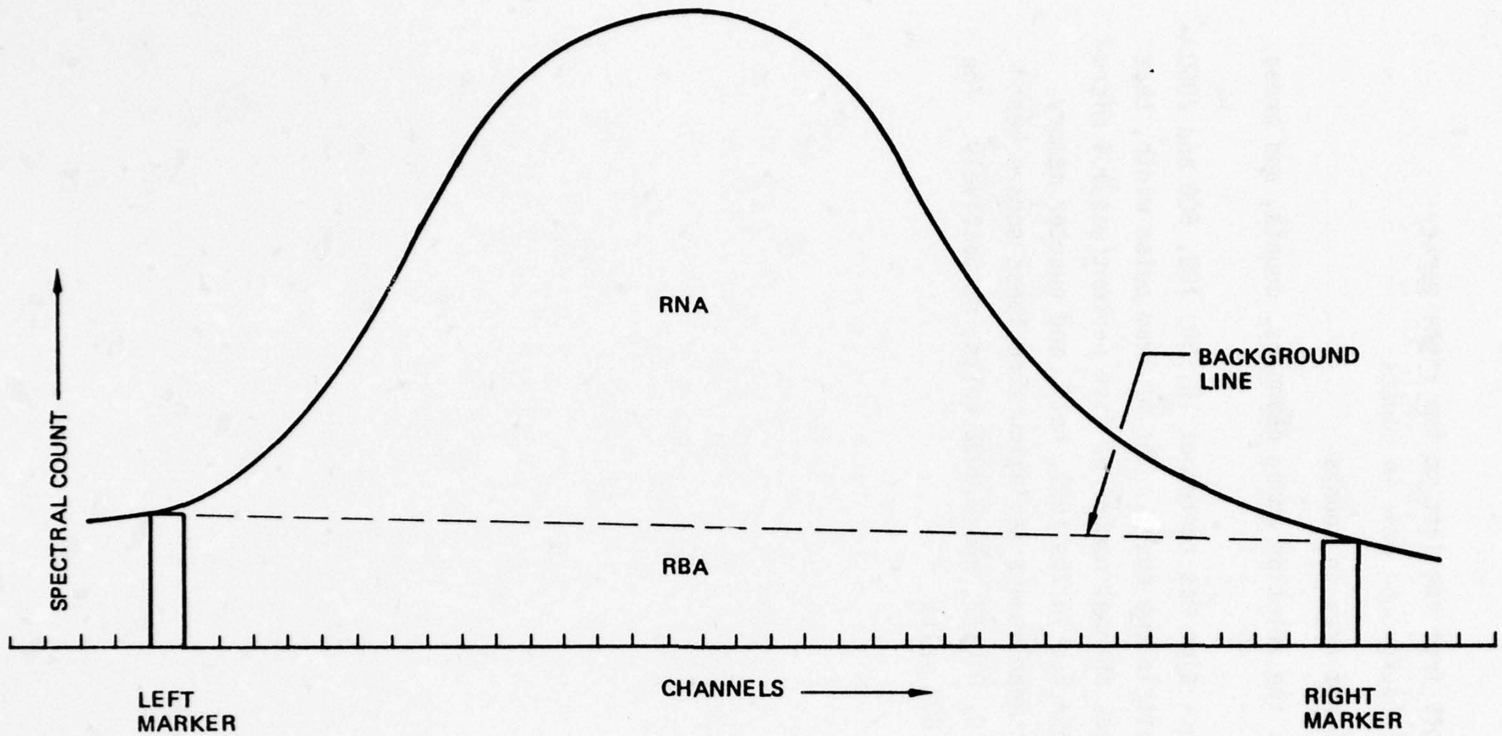


Figure 9: Relation of Spectral Counts and Channels

TABLE 14

CALIBRATION OF ND 60 WITH THE PARTIAL DISCHARGE INTERNAL CALIBRATOR

Biddle						ND 60	
Calibrator			Amplifier				
Charge Multiplier N	Charge PC	Picocoulombs PC	Gain N	Vernier	Scope cm	Channel	Counts
0.01	2	0.02	100	Max	0.05	---	0
0.01	5	0.05	100	Max	0.4	---	0
0.01	10	0.1	100	Max	0.8	17	451
0.01	20	0.2	100	Max	1.5	61	453
0.01	50	0.5	100	Max	3.75	184	512
0.01	100	1.0	100	Max	7.2	384	686
0.01	200	2.0	100	Max	Off Scale	Off Scale	---
0.1	1	0.1	100	Max	3.2	107	601
0.1	2	0.2	100	Max	3.4	93	571
0.1	5	0.5	100	Max	4.75	52	528
0.1	10	1.0	100	Max	7.7	15	1396
0.1	20	2.0	10	Max	1.5	59	1501
0.1	50	5.0	10	Max	3.5	174	1528
0.1	100	10	10	Max	7.2	379	1601
1.0	2	2	10	Max	1.3	43	977
1.0	5	5	10	Max	3.7	178	1001
1.0	10	10	10	Max	6.8	364	971
1.0	10	10	1	Max	0.6	13	1542
1.0	20	20	1	Max	1.4	57	1475
1.0	50	50	1	Max	3.7	180	1442
1.0	100	100	1	Max	7.2	384	1817
1.0	100	100	0.1	Max	0.7	18	1671
1.0	200	200	0.1	Max	1.5	66	1649
1.0	500	500	0.1	Max	4.0	202	1615
1.0	1000	1000	0.1	Max	7.5	406	1838
0.1	1000	100	1	Max	7.2	384	1853
0.1	500	50	1	Max	3.7	182	1449

TABLE 14

CALIBRATION OF ND 60 WITH THE PARTIAL DISCHARGE INTERNAL CALIBRATOR

(Continued)

Biddle						ND 60	
Calibrator			Amplifier				
Charge Multiplier N	Charge PC	Picocoulombs PC	Gain N	Vernier	Scope cm	Channel	Counts
0.1	200	20	1	Max	1.45	58	1498
0.1	200	2	10	Max	1.4	54	1537
0.1	500	5	10	Max	3.5	172	1436
0.1	1000	10	10	Max	7.0	377	1696
.01	10	0.1	100	Max	0.75	12	692
.01	20	0.2	100	Max	1.4	61	513
.01	20	0.2	100	7.5	1.0	37	683
.01	50	0.5	100	7.5	2.5	121	747
.01	100	1	100	7.5	5.2	262	722
0.01	50	0.5	100	7	1.0	32	912
0.01	98	0.98	100	7	2	87	913
0.01	147	1.47	100	7	3	143	861
0.01	194	1.94	100	7	4	196	874
0.01	241	2.41	100	7	5	249	881
0.01	285.6	2.856	100	7	6	299	861
0.01	334.5	3.345	100	7	7	351	919
0.01	382	3.82	100	7	8	415	719
0.01	429	4.29	100	7	9	471	982
0.01	486	4.86	100	7	10	Off Scale	---

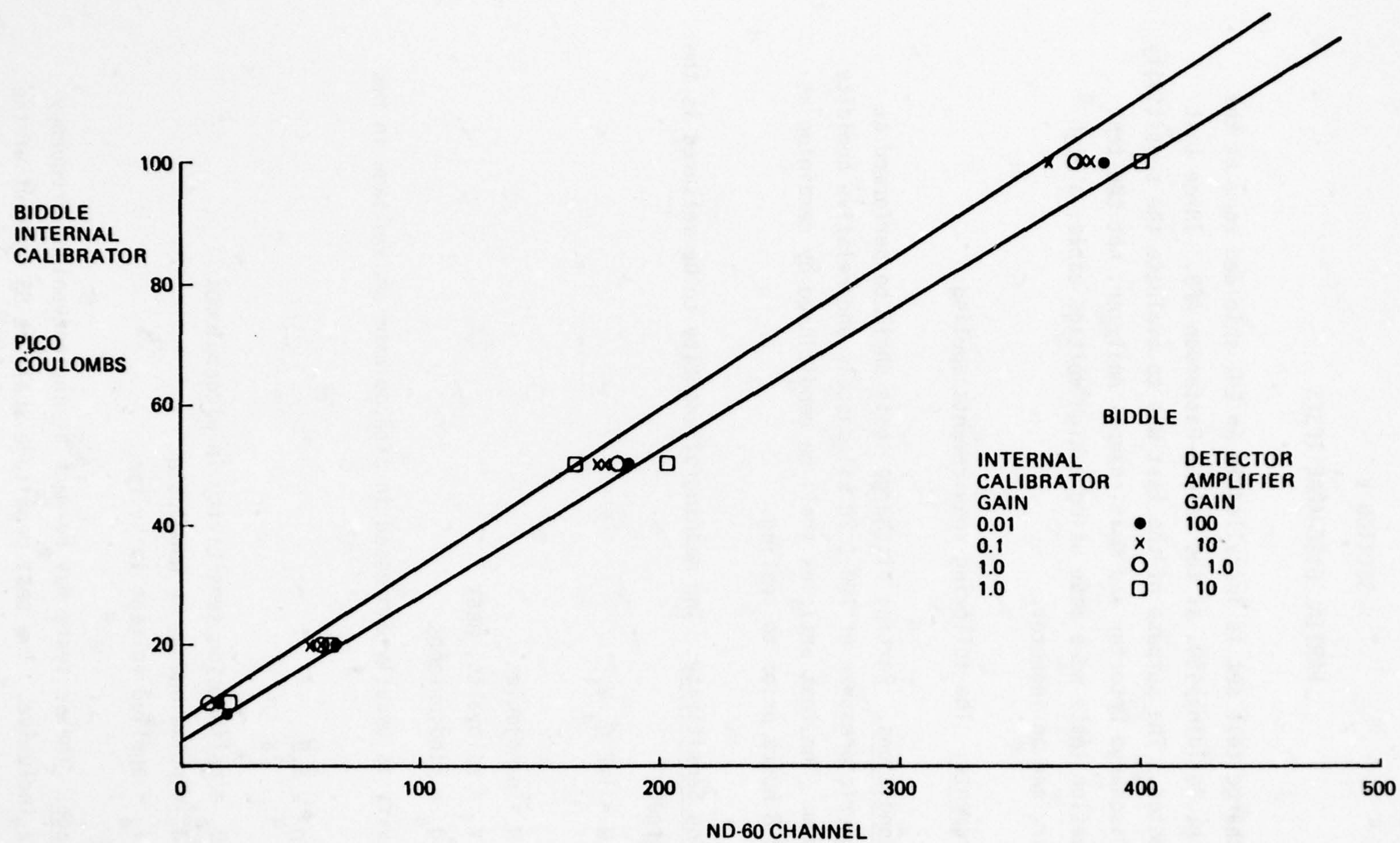


Figure 10: ND60 Channel to Internal Calibrator Conversion

SECTION V

PARTIAL DISCHARGE TESTS

The partial discharge test set is installed in an EMI shielded room at the High Power Branch, Building 450, at the Wright-Patterson AFB. Three test articles were tested. The purpose of the test was to evaluate the sensitivity of the Partial Discharge Detector and Multichannel Analyzer, not the test articles. Evaluation tests were made using a high voltage cable, a high voltage capacitor, and an inductor.

5.1 Test Requirements. The following requirements applied:

5.1.1 Ambient Conditions. Partial discharge tests shall be performed at 25 ± 5°C, atmospheric pressure of 100 ± 20 kilopascals and relative humidity 90 percent maximum. The test articles shall be conditioned by remaining at ambient at least 8 hours prior to testing.

5.1.2 Calibration Sensitivity. The meaningful quantity to be measured is the energy of discharge.

$$W = 1/2\ Q_a\ V_i$$

where

W = nanojoules

V_i = kilovolts, peak

Q_a = picocoulombs

Test set sensitivity is usually expressed in picocoulombs and voltage in rms units.

Therefore $Q_a = \frac{2\ W}{V_a}$

where Q_a = calibration sensitivity in picocoulombs

W = pulse energy in nanojoules

V_a = applied voltage in kv rms

5.1.3 Test Voltage. The ac tests may be made at any convenient frequency from 50 to 400 Hz inclusive. The test magnitude shall be 85 percent of the peak working voltage, where 120 percent rms equals 85 percent peak working voltage.

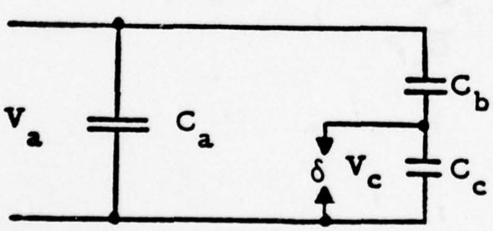
5.1.4 DC Voltage. When the test voltage is dc, the dc components shall equal the rated dc working voltage.

5.1.5 Rate of Application. The test voltage shall be raised uniformly from zero to 50 percent of maximum in not less than 5 seconds; from 50 percent to maximum the rate of rise shall not exceed 500 volts per second.

5.1.6 Duration of Tests. The tests shall be maintained for a minimum of 1 minute or 10,000 cycles, whichever occurs first, but not less than 15 seconds.

5.1.7 Enclosures and Fixtures. Because of the high voltages involved, means must be provided to prevent personnel from entering the high voltage hazard zone near the high voltage portion of the test equipment and test article. Also, extraneous electromagnetic and/or electrostatic coupling between the test circuit and test zone must be kept to a minimum so that there is no interference with the Partial Discharge Detector and display instrumentation. If the area has unusually strong interfering signals where the equipment and test article are installed, electromagnetic and electrostatic shielding of the entire enclosure may become necessary. Safety in operation and efficient shielding may be provided by installing the equipment in a shielded room with a solid earth grounding of the facility.

5.1.8 Magnitude and Energy of Discharge. When there is a discharge, it occurs as if the small capacitor C_c in the model circuit was instantaneously short-circuited. A charge transfer occurs, given by



V_a = applied voltage

$V_a = V_i$ = CIV

Q_a = apparent discharge magnitude detected at the terminals

$$Q_c = \left(C_c + \frac{C_a C_b}{C_a + C_b}\right) \delta V_c = \delta V_c \, \frac{C_a C_c + C_b C_c + C_a C_b}{C_a + C_b} \qquad (1)$$

Simultaneously, a voltage pulse, which is effectively a step voltage having a risetime of between 10 and 100 nsec is generated at the terminals of the insulation.

$$\delta V_a = \delta V_c \frac{C_b}{C_a + C_b} \tag{2}$$

The apparent discharge magnitude, observed at the terminals, is

$$Q_a = \delta V_a \left(C_a + \frac{C_b C_c}{C_b + C_c} \right) = \delta V_a \frac{C_a C_b + C_a C_c + C_b C_c}{C_b + C_c} \tag{3}$$

$$C_3 = C_a C_b + C_a C_c + C_b C_c \tag{4}$$

Usually, a small area of the discharge site is almost completely discharged, so that

$$\delta V_c \simeq V_c = V_i \frac{C_b}{C_b + C_c} \tag{5}$$

$$\frac{Q_c}{Q_a} = \frac{\delta V_c}{\delta V_a} \frac{C_3}{C_a + C_b} \frac{C_b + C_c}{C_3} \frac{\delta V_a}{\delta V_c} \frac{C_a + C_b}{C_b}$$
$$= 1 + \frac{C_c}{C_b} \tag{6}$$

If it is assumed that most of the charge is liberated from the region where $\delta V_c \rightarrow V_c$, the energy liberated will be

$$W = 1/2\, Q_c V_c = 1/2\, Q_a \left(1 + \frac{C_c}{C_b} \right) V_i \frac{1}{1 + \frac{C_c}{C_b}} = 1/2\, Q_a V_i \tag{7}$$

where

W = nanojoules

V_i = kilovolts peak

Q_a = picocoulombs

5.2 Test Equipment. Test equipment required for these tests is as follows:

5.2.1 Partial Discharge Test Facility by James G. Biddle Company

	Equipment	Part No.
1)	Detector	17000-3
2)	Power Separation	17187-2 17189-1
3)	Calibration Signal Coupler	9636
4)	DC Noise Filter	17396
5)	Ground Wand	22060

5.2.2 Multichannel Analyzer by Nuclear Data, Inc.

1)	Microprocessor Multichannel Processor	ND 60

5.2.3 Test Articles

1)	High Voltage Cable Assembly	HVX-1
1)	High Voltage Capacitor	HVX-2
1)	High Voltage Inductor	HVX-3

5.3 Test Article Preparation. The test articles shall be prepared for test with the following restrictions:

1) The test voltage shall not exceed the maximum working voltage of the test article

HVX-1	Cable Assembly	105 kvdc
HVX-2	Capacitor	150 kvdc
HVX-3	Inductor	2 kvdc

2) All high voltage surfaces shall be free of grease, dirt, and debris.

3) A good ground must be provided for the test equipment. Ground straps must be of 1/2" braid or larger.

5.4 High Voltage Cable Assembly, HVX-1. The high voltage cable assembly must be connected in the following manner:

CAUTION: The receptacle and plug must be protected with the provided plastic covers when unconnected.

a. Remove grease from plugs and receptacles with a lint-free wiper. The receptacles shall be connected to the high voltage test facility.

b. Apply a thin layer of silicone grease, General Electric G-661 preferred, everywhere on the insulation surface. The grease layer should not exceed 0.003 inch thick.

c. Plug the cable assembly into the receptacles and take up the coupling nut until the nut bottoms. Allow the grease to seat for 10 minutes. Retighten, if necessary.

d. This procedure should be repeated if the cable assembly is removed and reinstalled. There are no additional impedance matching requirements except those that are already provided by the test equipment.

5.4.1 Alternate Method. For a cable assembly without mating receptacles:

a. Remove grease from the plugs with a lint-free wiper.

b. Connect one plug high voltage connector to the high voltage test facility.

c. The plugs may be immersed into two containers of insulating fluid - freon or oil or be suspended in air. The containers shall be constructed of insulating materials.

d. The plugs and connection shall not touch the sides or bottom of the container. Two inches spacing is adequate.

5.5 High Voltage Capacitor, HVX-2

CAUTION: The shorting wire (bar) between terminals and/or ground shall be connected at all times, except when the capacitor is connected to the test facility.

The high voltage capacitor, HVX-2, shall be connected in the following manner:

a. The case shall be grounded.

b. The negative terminal shall be grounded.

c. Remove the shorting wire (bar) and the test facility probe to the high voltage terminal.

d. Ground the power separation filter at all times when the capacitor is unexcited.

e. Reattach the shorting wire (bar) when the unit is unconnected from the test facility.

5.6 Test and Adjustments.

5.6.1 Test Set. The Partial Discharge Test Set includes: 1) Partial Discharge Test Equipment and 2) a Multichannel Analyzer Microprocessor. The Partial Discharge Test Facility will be tested as a complete unit, then the Multichannel Analyzer Microprocessor will be added to complete the system test.

5.6.2 Continuity Check. Continuity of wiring for the Partial Discharge Test Facility shall be checked for conformance with Figures 2 and 11. The H.V. power supply shall be disconnected and turned off.

5.6.3 Partial Discharge Detector Checkout. Checkout of the partial discharge detector with the ND 60 "off" is as follows:

a. Turn on the Detector Unit and adjust grounds and leads to reduce noise level below 0.05 pC.

b. Calibrate the unit. Set gains and denote discrepancies with the Internal Calibrator.

c. Disconnect all calibrating equipment. Background noise shall be less than 0.05 pC. Adjust wiring to obtain that noise level.

d. Connect the direct current HV power supply. Adjust ground system to reduce noise level to less than 0.05 pC with the HV power supply "OFF".

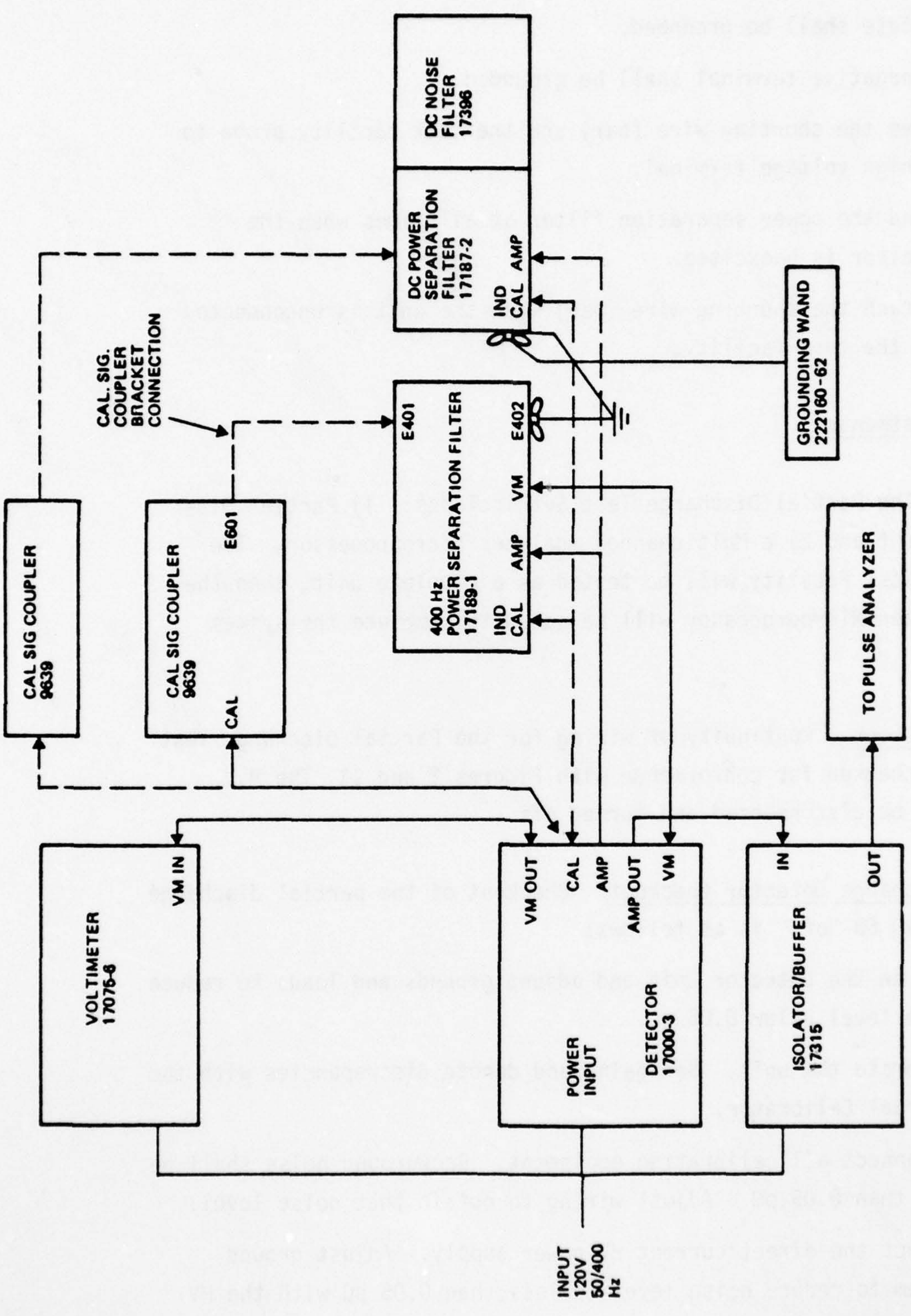


Figure 11: Corona Test System Schematic

e. Turn on the HV dc Power Supply. Record the noise level at voltage levels between 10 and 150 kv (in 10 kv steps). Add filtering between the HV power supply and filter unit to keep the noise level below 0.1 pC voltages above 100 kv. Increase the voltage at a rate of 500 volts per second.

f. De-energize the unit. Short the power supply and separation filter with the grounding wand. Grounding should be at least one minute after the high voltage output is 0 volts.

5.6.4 <u>Cable Test</u>. Connect the high voltage cable assembly, HVX-1, as shown in Figure 12. Perform tests as follows:

a. Remove the grounding wand.

b. Turn on the Partial Discharge Detector. The HV_{dc} Power Supply should remain off.

c. Record noise level at 0 volts dc output.

d. Adjust grounds on the cable assembly. Adjust to reduce the noise level to less than 0.05 pC.

e. Turn on the HV_{dc} Power Supply.

f. Record partial discharges for 1-minute periods at voltages between 10 KV and V max in 10 KV intervals. The voltage shall not be increased once the partial discharge peaks and exceed one 500 pC discharge per minute.

g. Record all data.

h. Reduce voltage to 0 volts; turn off the HV_{dc} power supply.

i. Discharge the high voltage units with the Grounding Wand.

j. Turn off the Detector.

k. Disconnect the cable assembly.

5.6.5 <u>Test Set Checkout</u>. Connect the output of the Partial Discharge Detector, Buffer/Isolator to the input of the ND 60 (Multichannel Analyzer Processor) as shown in Figure 8 ground the ND 60 to the Partial Discharge Detector ground. Calibrate the ND 60. Pulse heights and numbers shall be

AD-A069 473 BOEING AEROSPACE CO SEATTLE WASH F/G 9/5

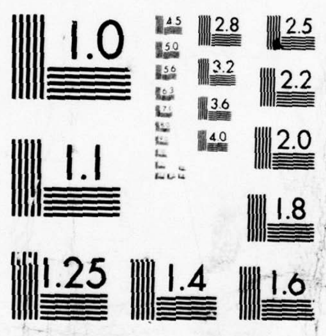
HIGH VOLTAGE SPECIFICATIONS AND TESTS (AIRBORNE EQUIPMENT). (U)

APR 79 W G DUNBAR, W P KOENIG F33615-77-C-2054

UNCLASSIFIED AFAPL-TR-79-2024 NL

2 OF 6

AD A069473


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

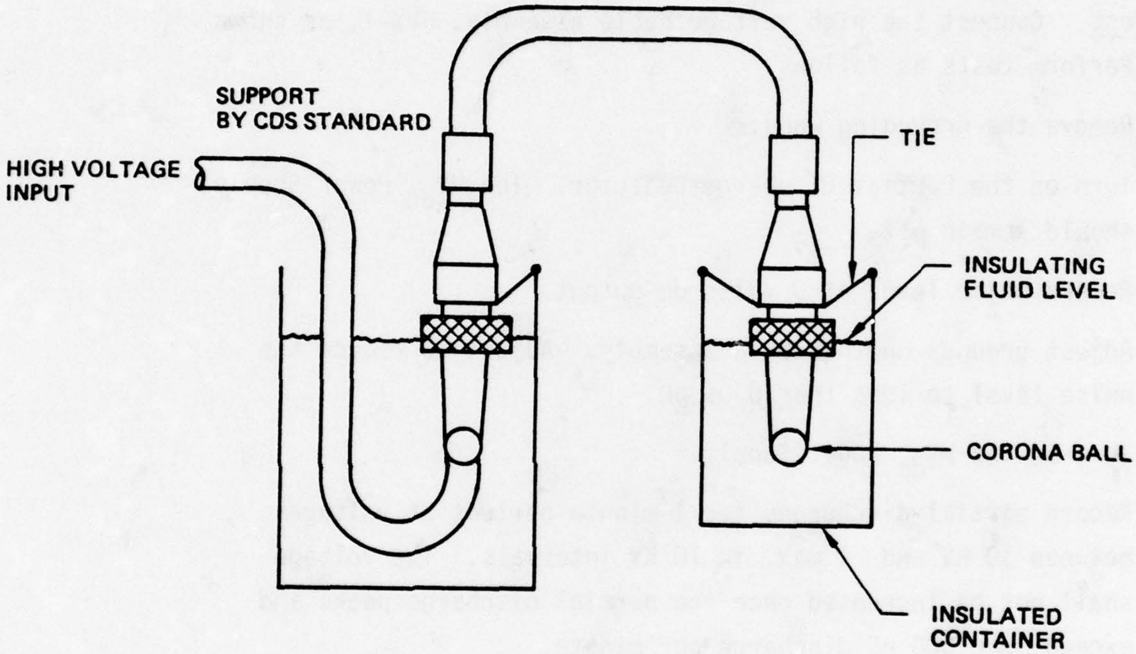


Figure 12: Cable Test Schematic

determined to calibrate the partial discharge detector; use the procedures of paragraph 5.6.3 and adjust the ND 60 to comply with the Partial Discharge Detector. Following the checkout and calibration, remove all calibration equipment, ground the HV equipment, and turn off the ND 60 and Partial Discharge Detector.

5.6.6 Test Set. Connect the facility as shown in Figures 11 and 12. Test the facility as follows:

a. Turn on the Partial Discharge Detector.

b. Adjust the ND 60 to receive signals 5 times the magnitude read out at 10 KV in the test of paragraph 5.6.4.

c. Turn on the ND 60.

d. Remove the Grounding Wand.

e. Turn on the HV Power Supply. The noise level should be less than 0.05 pC on the partial discharge detector.

f. Increase the voltage for 10 KV. Adjust the ND 60 for a reasonable readout. Record: pulse heights and pulses per second for two to three decades, i.e., a) 0.01 to 0.1, b) 0.1 to 1.0, etc., for a one-minute period. Record Partial Discharge Detector outputs also.

g. Repeat f) for applied voltages of 20 KV to V max, or the limit determined in paragraph 5.6.4.

h. Reduce the high voltage test to 0.

i. Turn off the HV Power Supply.

j. Turn off the Partial Discharge Detector and ND 60.

k. Discharge the high voltage equipment with the Grounding Wand.

l. Disconnect the Cable Assembly.

5.6.7 HV_{dc} Capacitor Test. Connect the capacitor into the circuit as shown in Figure 13 and repeat the test outlined in paragraph 5.6.6 for the high voltage capacitor.

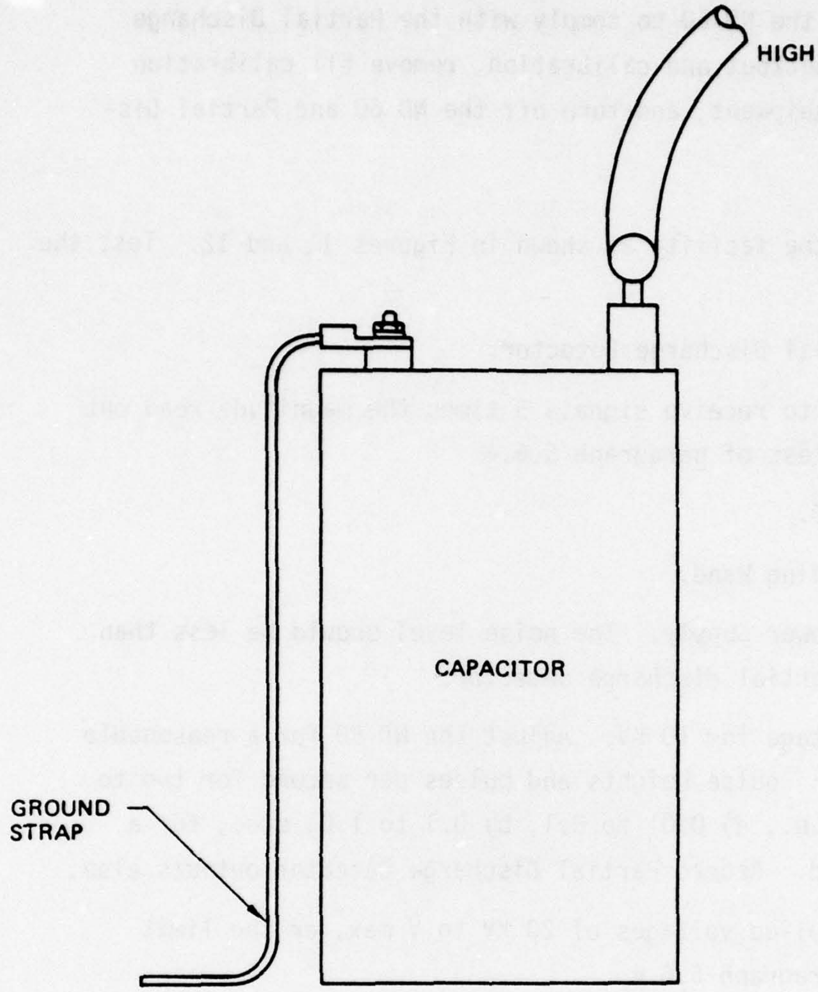


Figure 13: Capacitor Connection

5.6.8 High Voltage Inductor Test. Connect the inductor into the circuit and repeat the test outlined in paragraph 5.6.6 per the high voltage capacitor. This completes the system dc evaluation tests.

5.6.9 AC Voltage Test. The ac voltage test shall be performed using a 60 Hz high voltage power supply and the high voltage cable assembly, HVX-1.

5.6.10 Test. Connect the circuit as shown in Figure 11, with the dc noise filter disconnected. Repeat the test procedure outlined in paragraph 5.6.4. The following exceptions apply:

1) AC voltage tests shall be limited to 40 KV.
2) Voltage steps shall be in 5 KV increments.

5.6.11 Test Data. Data were taken for the three test samples, HVX-1, HVX-2 and HVX-3, and for the high voltage DC power supply. The high voltage power supply was very clean to 40 Kv, i.e., no noise above 0.2 pc. Above 40 Kv the noise level increased to 0.32 pc which correlates to channel 102 on the ND 60 as shown in Table 15. There were no partial discharges greater than 0.05 pc registered by the partial discharge detector on the ND 60 in a 10-minute period for the high voltage capacitor. The 2 Kv inductor had partial discharges above 1100 volts as shown in Table 16. The high voltage cable had numerous partial discharges starting at 20 Kv and 30 Kv. The test was terminated when the partial discharge became greater than 1000 pc, the design level for the cable. A summary of the test data is shown in Table 17.

TABLE 15 HV POWER SUPPLY PARTIAL DISCHARGE TEST

Applied Voltage Kilovolts	ND 60 Discharge Recorded for 1-Minute Period																	
	Channel	37	38	39	40	41	42	44	45	48	50	51	53	56	61	63	75	102
40		No spikes above 0.2 pc																
50	Counts	2	1	4	1		2	4										
55	Counts	4		5	1		1		1	1	1		1		1		1	
60	Counts	3	1	1		1					1	1		1		1		1
	PC	0.14	0.14	0.15	0.16	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.2	0.21	0.22	0.24	0.32

TABLE 16 HV INDUCTOR TEST

Applied Voltage V_{DC}	Partial Discharge Detector PC	ND 60 Channel (PC)
400	.01	
500	.01	
600	.01	
800	.01	
1150	.09	55 (0.2)
1400	.16	104 (0.32)
1700	.27	83 (0.29)
2000	.50	208 (0.59)
2250	.59	284 (0.8)
2500	.80	368 (1.0)

TABLE 17 CABLE TEST

Applied Voltage Kilovolts, dc	ND 60 Counts	Detector Gain	Picocoulombs
20	96	100	0.3
30 Initial	104	10	3.5
15 Minute Stand	508	10	145
30 Minute Stand	< 50	0.1	< 2000

SECTION VI

SPECIAL H.V. CONNECTIONS

Three special high voltage cables were fabricated for the partial discharge test set. These cables are to interconnect high voltage (over 20 Kv) test articles to the test set high voltage separation filter. The cable construction details are shown in Figures 14 and 15. The Materials List is shown in Table 18.

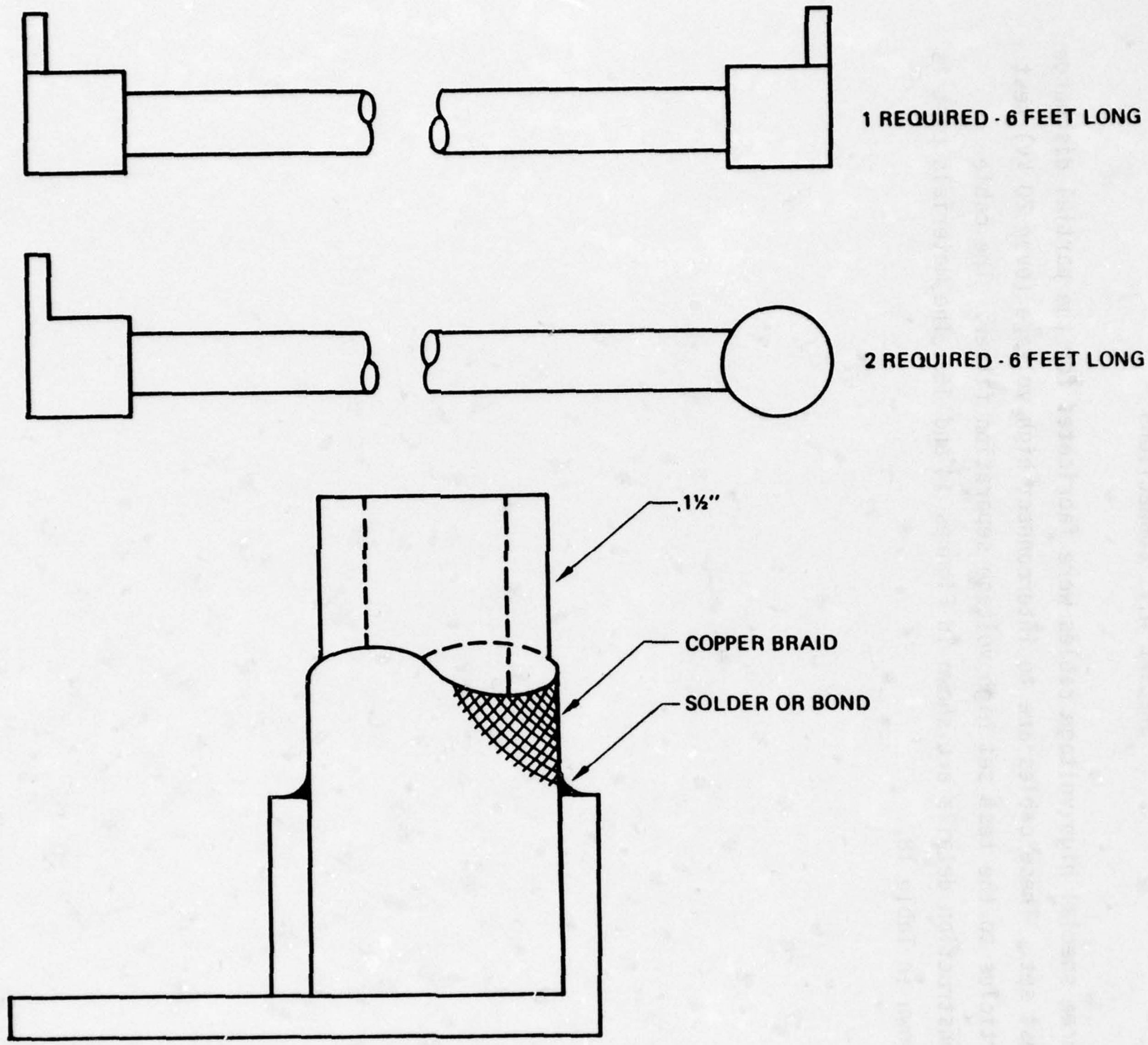


Figure 14: High Voltage Cables

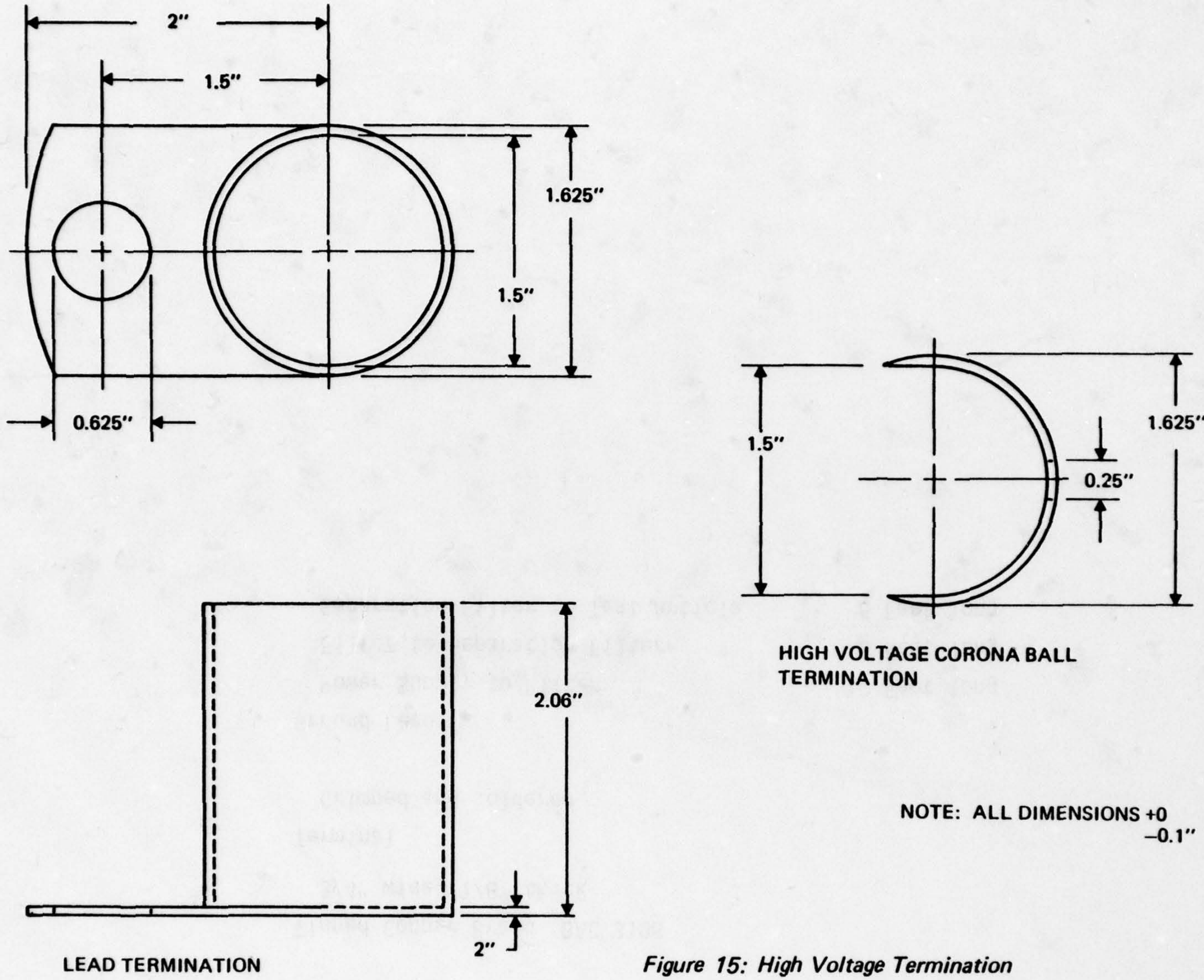


Figure 15: High Voltage Termination

TABLE 18. LIST OF MATERIALS

Tinned Copper Braid BAC 3108	
3/4" wide, 1/8" thick	
Terminal	
Crimped and soldered	
Ground Leads	
Power Supply to Filter	10 Feet long
Filter to Separation Filter	6 Feet long
Separation Filter to Test Article	6 Feet long

SECTION VII

TESTS

High voltage insulation, parts, components, and equipment are tested to evaluate their physical and electrical properties and to predict the service life of airborne equipment.

7.1 Materials Tests. Materials physical properties are measured in mechanical and chemical laboratories. Physical properties are usually well defined for most materials used in electrical applications. However, bonding flaws and accumulation of voids during encapsulation must be determined by measurement after encapsulation. These defects are measured with partial discharge detectors, insulation resistance test equipment, and dielectric withstanding voltage (hipot) instruments. The use of a partial discharge test set similar to one developed for this program, for detecting voids and bonding flaws is described in this section.

7.2 Partial Discharge Tests. Partial discharge tests are used to seek out insulation material flaws by detecting the partial discharges in voids, cracks, or gas filled spaces. The partial discharge test set measures the number of discharges and the pulse heights of the discharges. These data, when properly correlated with model test data, materials test data, and component test data can be used to predict the acceptance/rejection of the manufactured equipment.

7.3 Equipment Preliminary Test Parameter. The test parameters shown in this paragraph are preliminary. Some test parameters will increase significantly if inorganic materials are used rather than organic materials. The data listed herein are based on the use of organic materials.

7.3.1 Cable Assemblies. Cable assemblies include a unit consisting of a cable with two mated connector halves. Partial discharges should be limited to the pulse heights shown in Table 19.

TABLE 19 CABLE ASSEMBLIES

Applied Voltage KV_{DC}	Partial Discharge Picocoulombs Peak	Partial Discharge Picocoulombs Continuous
0 - 75	100	20
75 - 125	500	40
125 - 250	1000	50

Peak discharges shall be limited to one pulse every 10 minutes. Pulses attributed to test power line transients, when properly measured and recorded, may be discarded. These values shall be taken during thermal cycling during the first and last cycle of the test. A thermal cycle shall include temperature from room ambient to -55°C to room ambient to +85°C to room ambient. Soak time at -55°C and +85°C shall be as stated in the detailed specification under temperature cycling.

7.3.2 Capacitor. Capacitor test parameters shall use the same test conditions stated for the cable assemblies. The partial discharge test parameter by calculations should not exceed the values of Table 20.

TABLE 20 CAPACITORS

Applied Voltage KV_{DC}	Partial Discharge Picocoulombs Peak	Partial Discharge Picocoulombs Continuous
0 - 75	25	5
75 - 125	50	10
125 - 250	75	20

7.3.3 Converter. The converter will include a transformer, capacitor and solid state devices. The transformer and high voltage capacitors are covered by their own paragraphs. Parameters shown in Table 21 are for the solid state devices and the assembled converter. Test parameters include the high voltage cables and connector assembly, i.e. input and output.

TABLE 21. CONVERTERS

Test Circuit	Voltage KV	Partial Discharge Picocoulombs Peak	Partial Discharge Picocoulombs Continuous
Input	1-10	10	2
	10-40	25	5
	40-60	50	10
Output	0-75	125	25
	75-125	600	50
	125-250	1200	75

7.3.4 Power Source. The power source may be either an alternating current generator or a magnetohydrodynamic generator. In this report, it is assumed that an inorganic insulation will be used. In that case, the continuous partial discharges within the acceptable range may be as high as 500 to 10,000 PC, respectively. Data for the organic insulated materials are shown in Table 22.

TABLE 22. POWER SOURCES

Generator	Part	Voltage KV	Partial Discharge Picocoulombs Peak	Partial Discharge Picocoulombs Continuous
Alternator	Coils	0 - 1 rms	10	2
		1 - 25 rms	25	5
		25 - 50 rms	50	10
	Assembly	0 - 25 DC	100	10
	With Rectifier	0 - 50 DC	250	25
MHD	Assembly	2 - 50 DC	25	5
		5 - 20 DC	100	10

7.3.5 Transformers. Partial discharge measurements of the many coils and coil assemblies prior to final assembly during manufacture can result in cost and time saving. It is recommended that special fixtures be designed for testing coils, coil assemblies, and the transformer assembly. The partial discharge test parameters are shown in Table 23.

Table 23. TRANSFORMERS

Part	Voltage KV rms	Partial Discharge Picocoulombs Peak	Partial Discharge Picocoulombs Continuous
Coils	0-1	3	1
	1-5	3	1
	5-15	5	2
	15-25	8	3
	25-50	15	5
	50-100	50	10
	100-150	75	20
Coil Assemblies Phases	0-1	3	1
	1-5	5	1
	5-25	10	4
	25-50	25	7
	50-100	60	15
	100-150	125	25
	150-200	200	40
	200-250	300	50
Transformer	0-25	25	5
	25-50	50	10
	50-150	200	40
	150-250	500	75

Transformer assembly measurements shall be tested using high voltage laboratory test fixtures rather than the high voltage cable assemblies.

SECTION VIII

INTERIM REPORT DISTRIBUTION LIST

Seven of the eight criteria preliminary documents on high voltage, high power electrical equipment were issued for comment and critique to government agencies and industry. The distribution list is attached as Appendix I. These documents are:

- Cables
- Cable Assemblies
- Capacitors
- Connectors
- Converters
- Power Characteristics
- Transformers

The purpose of the interim report was to provide an opportunity for comments and critique by industry and Government agencies. The comments were to be directed to:

Hugh L. Southall, Captain USAF
US Air Force Aeropropulsion Laboratory
AFAPL/POD-1
Wright-Patterson AFB, Ohio 45433

Comments and critique were to be received before August 15, 1978 so that they could be screened, evaluated, and used to update the final report. It was requested that the comments and critique be referenced to the specific document by title and paragraph number.

SECTION IX

REFERENCES

(1) Sutton, J. E. and Stern, J. E., "Spacecraft High-Voltage Power Supply Construction," NASA TN D7948, Goddard Space Flight Center, Greenbelt MD, April 1975

(2) "High Voltage Design Guide for Airborne Equipment," AFAPL-TR-76-41, Air Force Aero Propulsion Laboratory, Air Force Systems Command, Wright Patterson Air Force Base, Ohio, June 1976.

(3) Bunker, E. R., Jr., "High Voltage Electronic Packaging for Electronic Equipment," Code Ident. No. 23835. Des. Reg. DM505139, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, November 1971.

(4) "Transformer and Inductors (Audio, Power and High Power Pulse) General Specification for," MIL-T-27, April 1974.

APPENDIX A

CABLES

CABLE, POWER, ELECTRICAL, INSULATED, HIGH VOLTAGE

GENERAL SPECIFICATIONS FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers electrically insulated cables for use on high voltage, limited life (1750 hours) applications.

1.2 Classification. Cables covered by this specification shall be classified as flexible high voltage constructions for power, communications, instrumentation and electronic applications.

Type I - Unshielded
Type II - Shielded

Grade A - Temperature range - 65°C to 85°C
Grade B - Temperature range - 65°C to 105°C
Grade C - Temperature range - 65°C to 200°C

Class 1 - Single conductor
Class 2 - Multiple conductor

1.3 Government designation. Government designations will be assigned to combinations of type, grade, class and size in the following manner:

Example

	Type		Upper Temperature Limit	Conductor
Spec. No.	S--Shielded (absence of ltr indicates unshielded).	Nominal Diameter (Millimeters)	L--Low (85°C) M--Medium (105°C) H--High (200°C)	S--Single M--Multiple
MIL-C-915E	S	40	M	S

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

O-E-7060 - Ethyl alcohol (Ethanol), Denatured Alcohol, and Proprietory Solvent.

QQ-W-343 - Wire, Electrical and Nonelectrical, Copper (Uninsulated).

MILITARY

MIL-C-572 - Cords, Yarns and Monofilaments, Organic Synthetic Fiber.

MIL-C-915 - Cable, Cord and Wire, Electrical (Shipboard Use).

MIL-W-3861 - Wire, Electrical (Bare Copper).

MIL-C-12000 - Cable, Cord and Wire, Electric, Packaging and Packing of.

MIL-F-13927 - Fungus Resistance Test; Automotive Components.

MIL-M-20693 - Molding Plastic, Polyamide (Nylon), Rigid.

STANDARDS

FEDERAL

FED-STD-595 - Colors

FED-STD-228 - Federal Test Method No. 228, Cable and Wire, Insulated; Methods of Testing

FED-STD-601 - Federal Test Method No. 601, Rubber: Sampling and Testing.

MILITARY

MIL-STD-104 - Limits for Electrical Insulation Color.

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.

MIL-STD-129 - Marking for Shipment and Storage

MIL-STD-130 - Identification Marking for U.S. Military Property.

MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.

MIL-STD-461A -Electromagnetic Compatibility

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM-B 3 - Soft or Annealed Copper Wire.
ASTM-B 8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
ASTM-B 33 - Tinned Soft or Annealed Copper Wire for Electrical Purposes.
ASTM-B 172 - Rope-Lay Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors.
ASTM-B 173 - Rope-Lay Stranded Copper Conductors Having Concentric Members, for Electrical Conductors.
ASTM-B 174 - Bunch-Stranded Copper Conductors for Electrical Conductors.
ASTM-B 189 - Lead-Coated and Lead Alloy-Coated Soft Copper Wire for Electrical Purposes.
ASTM-B 193 - Resistivity of Electrical Conductor Materials, Test for.
ASTM-B 228 - Concentric-Lay-Stranded Copper Clad Steel Conductors.
ASTM-B 258 - Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors.
ASTM-B 286 - Copper Conductors for Use in Hookup Wire for Electronic Equipment.
ASTM-B 298 - Silver-Coated Soft or Annealed Copper Wire.
ASTM-B 355 - Nickel-Coated Soft or Annealed Copper Wire.
ASTM-D 297 - Rubber Products, Chemical Analysis of.
ASTM-D 470 - Testing of Rubber and Thermoplastic Insulated Wire and Cable.
ASTM-D 1458 - Fully Cured Silicone Rubber-Coated Glass Fabric and Tapes for Electrical Insulation, Testing.

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

UNDERWRITERS' LABORATORIES, INC.

(Application for copies of publications should be addressed to Underwriters' Laboratories, Inc. 1285 Walt Whitman Road, Melville, New York 11746 or 207 East Ohio Street, Chicago, Illinois 60611.)

AMERICAN NATIONAL STANDARDS INSTITUTE, INC.

C96.1 - Temperature Measurement Thermocouples

(Application for copies should be addressed to American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
Insulated Power Cable Engineers Association (IPCEA)
Publication No. S-66-524 - Cross-linked-thermosetting-polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA Publication No. WC 7-1971).

(Application for copies should be addressed to National Electrical Manufacturers Association, 155 East 44th Street, New York, N. Y. 10017.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 Detail requirements. Detail requirements or exceptions to the general requirements specified herein shall be as specified by the specification sheet. In the event of any conflict between the general requirements of this specification and the specification sheet, the latter shall govern.

3.2 Qualification. Cables furnished under this specification shall be products which have been tested and passed the qualification tests listed herein.

3.2.1 Requalification. Changes in materials and constructions shall require the written approval of the cognizant government procurement agency. Incorporation of any changes which have not been so approved shall require requalification of the cable or groups of cables in question.

3.3 Materials. All materials used in the construction of those cables requiring qualification shall have the written approval of the cognizant government procurement agency. In the case of cables or cords not requiring qualification, approval will not be required, and all materials in these cables shall conform to the requirements shown in the applicable specification sheets.

3.3.1 Conductors.

3.3.1.1 Standard copper conductors. Standard copper conductors shall be composed of soft or annealed copper strands conforming to ASTM-B 3.

3.3.1.2 High strength conductors. Unless otherwise specified on the specification sheet high strength conductors shall be composed of 30 percent conductivity, high strength, copper-covered steel strands conforming to ASTM-B 228.

3.3.1.3 Tin coating. Tin coating shall be commercially pure tin conforming to ASTM-B 33.

3.3.1.4 Lead or lead-alloy coating. Lead or lead alloy coating shall conform to ASTM-B 189.

3.3.1.5 Nickel coating. Nickel coating shall conform to Class 2 of ASTM-B 355.

3.3.2 Insulation. The insulation shall be applied concentrically about the conductor and so cured, processed, or maintained as to provide for accurate centering of the conductor and retention of a circular cross-section. At any cross-section along the length of the completed wire, the eccentricity of the center conductor shall be less than five percent of the difference between measured diameter over insulation and measured diameter over conductor. Measurements to determine concentricity shall be made upon the primary insulation only and shall not include the thickness of the semi conducting insulation.

3.3.3 Jacket. When a polyamide, polyvinyl, FEP-fluorocarbon, neoprene, or TFE-fluorocarbon jacket is specified (see 6.2) a tight fitting concentric tube shall be applied. The increase in diameter, that is, the difference between the measured diameter under the jacket and the measured diameter over the jacket shall be not less than one millimeter or more than four millimeters.

3.3.3.1 Polyamide jacket. Polyamide jacket material shall conform to type III, grade E, of Specification MIL-M-20693. Unless circuit identification is applied to the jacket, it shall be sufficiently transparent so as not to impair any underlying color coding.

3.3.3.2 Polyvinyl jacket. Polyvinyl jacket material, shall be a polyvinyl chloride or its copolymer with polyvinyl acetate.

3.3.3.3 FEP-fluorocarbon jacket. FEP-fluorcarbon jacket material shall be fluorinated ethylene propylene. Unless circuit identification is applied to the jacket, it shall be sufficiently transparent so as not to impair any underlying color coding.

3.3.3.4 TFE-fluorocarbon jacket. TFE-fluorocarbon jacket material shall be polytetrafluoroethylene.

3.3.3.5 Neoprene. Neoprene jacket shall conform to MIL-R-3065.

3.3.4 Shields. The materials and constructions for shields of insulated conductors, groups of insulated conductors and overall cable shall be as required by the specification sheet. When AWG sizes are specified for wire shields, they shall be in accordance with ASTM-B 258. When a shield is specifically required, a closely woven braid of coated copper strands shall be applied to provide coverage of not less than 90 percent when determined by the following formula:

$$K = (2F - F^2) \times 100$$

Where:

K = Percent coverage.
a = Angle of braid with axis or cable.
Tan a = 2 (D + 2d) P/C.
d = Diameter of individual braid wire, in inches.
C = Number of carriers.
D = Diameter of cable under shield, in inches.
F = NPd/ sin a.
N = Number of wires per carrier.
P = Picks per inch of cable length.

3.3.4.1 Before braiding, strands shall conform to the requirements for conductors (see 3.3.1). The metallic coating on the copper strands of the shield shall be similar to the metallic coating of the conductor of the wire to which the shield is applied, unless otherwise specified. The braided shield shall not increase the maximum diameters of the type specified by more than 0.030 inch.

3.3.5 Tapes. Tapes shall be of the material as specified in the specification sheet or shall be a type approved for the specific cable construction.

3.3.6 Braids (identification). Colored braids used for conductor identification shall be of rayon in accordance with MIL-C-572.

3.3.7 Braids (glass). Glass braids for use on silicone insulated conductors shall be composed of the appropriate size of either staple or continuous fiber conforming to MIL-Y-1140.

3.4 Construction.

3.4.1 Conductor stranding. The size and quantity of individual conductor strands and the total circular-mil area of each conductor shall be in accordance with **Table A1,** as applicable in accordance with the size designation specified by the specification sheet.

3.4.1.1 Concentric-lay-stranded. The length and direction of lay and the type and number of joints in concentric-lay-stranded conductors shall be in accordance with ASTM-B 8 and ASTM-B 286, as applicable.

3.4.1.2 Rope-lay-conductor. The length and direction of lay and the type and number of individually insulated and uninsulated conductors in a rope-lay-conductor shall be in accordance with ASTM-B 172 or ASTM-B 173 as applicable.

Table A1 - Conductor data, concentric-lay stranded (ASTM B-286).

Conductor Size ASTM-B286 designation	Number of Strands (minimum)	Strand Diameter, Nominal (inch)	Conductor Diameter, Nominal (inch)	Conductor cross-sectional area, nominal (circular mils)	Weight per 1000 feet approximate (pounds)
12-37	37	0.0126	0.088	5874	20.20
12-19	19	.0179	.091	6088	20.20
14-19	19	.0142	.072	3831	12.65
16-19	19	.0113	.057	2426	7.97
18-19	19	.0100	.051	1900	5.02
18-7	7	.0159	.049	1770	5.02
20-19	19	.0080	.041	1216	3.16
22-7	7	.0126	.038	1111	3.16
22-19	19	.0063	.032	754	1.98
22-7	7	.0100	.031	700	1.98
24-19	19	.0050	.026	475	1.24
24-7	7	.0080	.025	448	1.24
26-19	19	.0040	.021	304	.780
26-7	7	.0063	.020	278	.780
28-19	19	.0031	.016	183	.490
28-7	7	.0050	.016	175	.490
30-7	7	.0040	.013	112	.309

3.4.2 Insulation.

3.4.2.1 Extruded insulation. Extruded insulations shall be applied concentrically and to the dimensions required by the specification sheet.

3.4.2.2 Taped insulation. Tapes used as insulation shall be applied in such a manner that they lie smoothly and free from wrinkles and voids. The tape width shall be proper for the diameter over which it is applied so as to minimize splits, creases and edge tears when the completed cable is subjected to bending. Registrations shall be held to a minimum, consistent with the best commercial practice.

3.4.2.3 Semicon-Inner. An inner layer of semi conducting insulation (semicon) shall be extended over the center conductor(s) to provide a continuous concentric circular surface for bonding of the primary insulation.

3.4.2.4 Insulation-Primary. The primary insulation shall be extruded over and bonded to the inner semicon. This construction will provide a voidless construction in the area of maximum electrical stresses. The primary insulation shall be compatible with the inner semicon to provide good bonding capability.

3.4.2.5 Semicon-Outer. An outer layer of semicon shall be put over the primary insulation. This semicon layer should be obtained as an extruded layer with a good cohesive bond to the primary insulation. As a minimum, a semicon ink shall be put over the extruded primary insulation under a semicon tape. The use of tape alone entraps air at each overlap joint which is susceptive to partial discharging under electrical stresses.

3.4.3 Shielding. Shielding for type II cable shall consist of a close and uniform woven wire applied direcly over the outer semicon layer. Each carrier shall have no less than five 0.006 inch diameter (number 34 AWG) wires.

3.4.3.1 Splices. Spliced wires shall average no more than 1 per 10 feet of cable.

3.4.3.2 Coverage. The shielding shall provide no less than 90 percent coverage of the underlying sheath. Percent of coverage shall be calculated as follows:

$$K = (2F - F^2) \times 100$$

Where:

K - Percent coverage
a - Angle of braid with axis of cable

Percent coverage (K) = 100 $(2F-F^2)$

Where:

F = NPd/Sin a
Tan a = 2 (D + 2d) P/C
a = acute angle of braid with axis of cable or cord
d - diameter (inch) of individual braid wires
D = diameter (inch) of cable under braid
N = number of wires per carrier
C = number of carriers
P = picks per inch of cable or cord length

3.4.4 Centering and Circularity

3.4.4.1 Insulation. The insulation over the inner semicon and individual conductors shall be uniform in diameter throughout the conductor length. At any cross section, the maximum wall thickness shall not exceed the minimum by more than 10 percent for specified thickness greater than 0.25 inch, nor by more than 20 percent for specified thicknesses of 0.25 inch and less.

3.4.4.2 Cable or cord jacket. The cable jacket shall be applied concentrically to the cable core in a manner to maintain circularity in the completed cable. The maximum wall thickness of the jacket at any cross section shall not exceed the minimum by more than 25 percent.

3.4.5 Dimensional tolerances. Where minimum or maximum dimensions, or both, are specified, no minus or plus tolerances, respectively, will be permitted. Where a dimension is specified as nominal, the average dimension shall be not less than the specified nominal. Where no minimum overall cable diameter is specified, the minimum permissible diameter shall not be less than 92-1/2 percent of the specified maximum overall cable diameter.

3.4.5.1 Conductor insulation wall thickness. For conductor insulation wall thickness specified as nominal, the average thickness shall be not less than the specified nominal. The minimum thickness, measured at any cross section, shall be not less than 90 percent of the specified nominal.

3.4.5.2 Cable jacket thickness. The average thickness of a cable jacket measured at any cross section shall be not less than the specified nominal. In case of multiconductor cables the jacket thickness shall be determined from the measurements made at the high point of each conductor taken on a line through the center of the cable and through the center of the cable and through the center of each conductor in the outer layer. The minimum thickness at any cross section shall be not less than 80 percent of the specified nominal.

3.4.6 Identification codes and methods. Individual conductors and groups of conductors shall be separately identified. The applicable identification code and the method by which the code is applied shall be specified in the specification sheet.

3.4.6.1 Identification codes.

3.4.6.1.1 Standard identification code. Standard identification code shall be in accordance with table A2.

Table A2 - Standard Identification code.

Color, conductor or group No.	Background or base color
1	Black
2	White
3	Red
4	Green
5	Orange

3.4.6.2 Manufacturer's identification tape. Unless otherwise indicated on the specification sheet, all cables shall contain a continuous, thin, moisture-resistant marker tape, a shrink-fit marking material, not less than 1/10 inch wide. The marker tape shall be placed directly over the cable jacket unless otherwise approved. The tape shall be printed to show the following information at intervals not greater than 1 foot: Name and location of manufacturer; year of manufacture; specification number (MIL-C-915); and progressive serial number. The serial number is not necessarily a footage marker. A serial number shall not be repeated by a manufacturer in any one year for any one type and size of cable or cord.

3.4.7 Surface condition. The surface of the cable jacket of all shielded and unshielded cables shall be dry and free from any coating, film or treatment which would tend to interfere with the bonding to it of encapsulating or molding materials normally used in splicing and terminating.

3.5 Electrical operational requirements. Unless otherwise specified (see 3.1), the electrical operational requirements shall be as specified herein.

3.5.1 Continuity. When cables are tested as specified in 4.8.2, each conductor and shield shall be continuous.

3.5.2 Spark tests. When cables are tested as specified in 4.8.3, there shall be no breakdown, flashover, or sparkover.

3.5.3 Voltage withstanding. When cables are tested as specified in 4.8.4, there shall be no breakdown, flashover, or sparkover.

3.5.4 Insulation resistance. When cables are tested as specified in 4.8.5, the insulation resistance per 1,000 feet shall be as specified (see 3.1).

3.5.5 Corona test. When cables are tested as specified in 4.8.6, the corona extinction voltage shall be as specified (see 3.1). When specified (see 3.1), the corona extinction voltage test shall also be performed at simulated altitude levels and the corona extinction voltage shall be as specified (see 3.1).

3.5.6 Capacitance. When cables are tested as specified in 4.8.7, the capacitance shall be as specified (see 3.1).

3.5.7 High temperature and altitude resistance. When tested in accordance with 4.8.8, cable shall evidence no sheath or insulation breakdown or corrosion of the conductor.

3.5.8 Impulse test. When cables are tested as specified in 4.8.9, there shall be no momentary or intermittent arcing or other indication of flashover or breakdown, nor shall there be any evidence of damage.

3.5.9 Ozone. All internal and external materials shall be resistant to ozone. The manufacturer shall certify that all materials are ozone resistant or shall perform the tests specified in 4.8.20. There shall be no evidence of ozone damage to the external surface of the cable.

3.5.10 Electromagnetic compatibility. When cables are tested as specified in 4.8.21, the cable shall have a shielding effectiveness of 15 dB minimum, **and electrical field effectiveness of 45 dB.** minimum.

3.6 Physical operational requirements. All physical operational requirements of the completed cable and cable components shall be as required by the specification sheet.

3.6.1 Diameter measurements. When cables are examined as specified in 4.8.1.1, the diameter measurements shall be as specified (see 3.1).

3.6.2 Out-of roundness of jacket measurements (when specified, see 3.1). When cables are examined as specified in 4.8.1.2, the out-of roundness of the jacket diameter dimensions shall be as specified (see 3.1).

3.6.3 Eccentricity of inner conductor. When cables are examined as specified in 4.8.1.3, the displacement of the inner conductor shall not exceed 10 percent of the core radius, unless otherwise specified (see 3.1).

3.6.4 Adhesion of conductors. When cables are tested as specified in 4.8.1.4, the adhesion of the inner conductor to the dielectric core and the adhesion of the dielectric core to the outer conductor shall be as specified (see 3.1).

3.6.5 Mechanically induced noise voltage (for low noise cables only). When cables are tested as specified in 4.8.10, the mechanically induced noise voltage shall not exceed the specified value (see 3.1).

3.6.6 Aging stability. When cables are tested as specified in 4.8.11, there shall be no evidence of cracks, flaws, or other damage in the jacket material.

3.6.7 Stress crack resistance. When cables are tested as specified in 4.8.12, there shall be no evidence of cracks, flaws, or other damage in the jacket material.

3.6.8 Outer conductor integrity. When cables are tested as specified in 4.8.13, there shall be no evidence of cracks, flaws, or other damage in the outer conductor material.

3.6.9 Cold Bend. When cables are tested as specified in 4.8.14, there shall be no evidence of cracks, flaws, or other damage in the jacket material of flexible cables or the dielectric core material of flexible or semirigid cable

3.6.10 Dimensional stability. When cables are tested as specified in 4.8.15, the measurement at each end shall not exceed the specified value (see 3.1).

3.6.11 Bendability. When cables are tested as specified in 4.8.16, there shall be no cracks, splits, fracturing, wrinkling, or other damage in the solid outer conductor material, after being formed around the mandrel diameter specified (see 3.1).

3.6.12 Flammability. When tested in accordance with 4.8.17, no burning or charred particles shall fall from the cable and the flame shall not travel along the cable at a rate of more than 1/2 inch per minute.

3.6.13 Fungus resistance. After testing in accordance with 4.8.18 cable shall meet the requirements of 3.5.3.

3.6.14 Anti-icing fluid resistance. When tested in accordance with 4.8.19 cable shall evidence no cracking, breaking, or separation, and shall subsequently meet the requirements of 3.5.3.

3.7 Repair of insulation or cable or cord jacket. Repair of cable jacket will not be permitted unless the materials and techniques used are such that the finished cable complies with all the requirements of this specification. The materials and techniques used in the repair of either insulation or cable jacket shall be subject to approval by the cognizant procurement agency. The frequency of repairs shall be held to a minimum.

3.8 End seals. All cables covered by this specification shall have both ends of each shipping length sealed to prevent the entrance of moisture. Materials used for end seals and method of application shall have the written approval of the cognizant procurement agency.

3.8.1 Shielded cables. All shielded cables covered by this specification shall have both ends of the center conductor(s) shorted to the shield during shipping and storage.

3.9 First article. When specified (see 6.2), the contractor shall furnish a cable sample for first article inspection and approval (see 4.2.1).

3.10 Marking. Cables shall be marked with the part number, military specification number, manufacturer's code symbol and name, in accordance with the basic requirements of MIL-STD-130. The marking shall be done in such a manner as not to permanently indent, deform or otherwise damage the jacket or outer covering. The first 25 feet of cable sample unit shall be examined for the marking requirements. The marking shall be visible and legible from the outside of the cable, except for armored cables. The marking shall be legible after the aging stability and stress crack resistance tests. The following details shall apply:

(a) Cable with jackets whose nominal diameter is greater than 0.15 inch shall be surface marked at intervals not exceeding 2 feet.
(b) Cables with jackets whose nominal diameter is less than 0.15 inch diameter need not be marked.

3.11 Workmanship. All cables shall be manufactured and processed in such a manner as to be uniform in quality and shall be free from any burrs, die marks, chatter marks, foreign material and other defects that will affect life, serviceability, or appearance. Workmanship shall be such as to enable the cable to meet the applicable requirements of this specification.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

4.2 Examination. A sample from each reel shall be examined for compliance with the requirements specified in section 3 of this specification. Noncompliance with any specified requirements or presence of one or more defects preventing or lessening maximum efficiency shall constitute cause for rejection.

4.2.1 First article inspection. First article inspection shall be performed on one reel of cable when a first article sample is required. This inspection shall include the examination of 4.2 and the tests of 4.3. The first article may be a standard production item from the supplier's current inventory provided the reel and cable meets the requirements of the specification and is representative of the design, construction, and manufacturing technique applicable to the remaining reels and cable to be furnished under the contract.

4.3 Inspection conditions. Unless otherwise specified herein, all test inspection conditions shall be performed in accordance with the test conditions specified in the "General Requirements" of MIL-STD-202, as follows:

a. Temperature: $25^{o}C \pm 10^{o}C$.
b. Relative humidity: 60 percent $\pm$15 percent.
c. Atmospheric pressure: 950 $\pm$ 100 Newtons/square meter.

4.4 Materials inspection. Materials inspection shall consist of certification supported by verifying data that the materials listed in table A3, used in fabricating the cables, are in accordance with the applicable referenced specifications or requirements prior to such fabrication.

TABLE A3. Materials inspection.

Material	Requirement paragraph	Applicable documents
Braids	3.3.6	MIC-D-572
tetrafluorethylene (TFE)	3.3.3.4	ASTM D-3159
Ethylene chlorotrifluoroethylene (E-CTFE)	3.5.6(m)	ASTM D-3275
Fiberglass	3.3.7	MIL-Y-1140
Fluorinated ethylene propylene (FEP)	3.3.3.3	L-P-389
Ozone	3.5.9	4.8.20
Polyamide	3.3.3.1	MIL-M-20693
Polyvinyl	3.3.3.2	
Rubber, insulating synthetic	3.3.3.5	ASTM D-470
Rubber, synthetic, semiconductor	3.4.2.3	FED-STD-601
Shields	3.3.4	ASTM B-258
Wire, copper, bare	3.3.1.1	ASTM B-3
Wire, copper, lead or lead alloy	3.3.1.4	ASTM B-189
Wire, copper, nickel coating	3.3.1.5	ASTM B-355
Wire, copper, tin-coated	3.3.1.3	ASTM B-33
Wire, steel, copper-clad	3.3.1.2	ASTM B-228

4.5 In-process inspection. During the manufacturing of cable, the tests in table A4 shall be performed, as applicable. Tests shall be performed on each continuous length of cable.

4.5.1 Failure. One or more failures shall be cause for refusal, except a spark test failure may be repaired or the cable length cut out.

TABLE A4. In-process inspection.

Tests	Requirement paragraph	Test Paragraph
Continuity	3.5.1	4.8.2
Spark test	3.5.2	4.8.3
Voltage withstanding	3.5.3	4.8.4
Insulation resistance	3.5.4	4.8.5

4.6 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.2) on sample units produced with equipment and procedures normally used in production.

4.6.1 Sample. The sample of each cable type submitted for qualification inspection shall be of sufficient length to perform all the applicable tests in table A5.

4.6.2 Inspection routine. The samples shall be subjected to the inspections specified in table A5. The entire sample shall be subjected to the inspection of group I. The specimen length shall be cut from each sample as required, and subjected to inspections of group II.

4.6.3 Retention of qualification. To retain qualification, the supplier shall forward a report at 12-month intervals to the qualifying activity. The qualifying activity shall establish the initial reporting data. The report shall consist of:

a. A summary of the results of the tests performed for inspection of product for delivery (groups A and B, paragraph 4.7), indicating as a minimum the number of lots that have passed and the number that have failed. The results of tests of all reworked lots shall be identified and accounted for.

b. A summary of the results of tests performed for qualification verification inspection group C, including the number and mode of failures. The summary shall include results of all qualification verification inspection tests performed and completed during the 12-month period. If the summary of the test results indicates nonconformance with specification requirements, and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list.

Failure to submit the report within 30 days after the end of each 12-month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the supplier shall immediately notify the qualifying activity at any time during the 12-month period that the inspection data indicates failure of the qualified product to meet the requirements of this specification.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item. If during three consecutive reporting periods there has been no production, the manufacturer may be required, at the discretion of the qualifying activity, to submit representative cables of each type to testing in accordance with the qualification inspection requirements.

TABLE A5. Qualification inspection.

Examination or test	No. of specimens to be tested	Requirement paragraph	Test paragraph
Group I			
In-process inspection	Entire sample		4.5
Continuity	Entire sample	3.5.1	4.8.2
Spark test	Entire sample	3.5.2	4.8.3
Voltage withstanding	Entire sample	3.5.3	4.8.4
Insulation resistance	Entire sample	3.5.4	4.8.5
Visual and mechanical examination	Entire sample	3.6	4.8.1
Physical dimensions	Entire sample	3.6	4.8.1
Marking	Entire sample	3.10	4.8.1
Workmarship	Entire sample	3.11	4.8.1
Group II			
Corona	2	3.5.5	4.8.6
Electromagnetic Compatibility	2	3.5.10	4.8.21
Capacitance	1	3.5.6	4.8.7
High Temperature and Altitude Resistance	2	3.5.7	4.8.8
Mechanically induced noise voltage	1	3.6.5	4.8.10
Aging stability	2	3.6.6	4.8.11
Stress-crack resistance	2	3.6.7	4.8.12
Outer conductor integrity	2	3.6.8	4.8.13
Cold bend	2	3.6.9	4.8.14
Dimensional stability	1	3.6.10	4.8.15
Bendability	2	3.6.11	4.8.16
Flammability	1	3.6.12	4.8.17
Fungus	1	3.6.13	4.8.18
Anti-icing fluid resistance	1	3.6.14	4.8.19
Impulse test	1	3.5.8	4.8.9

4.7 <u>Quality conformance inspection</u>.

4.7.1 <u>Inspection of product for delivery</u>. Inspection of product for delivery shall consist of groups A and B inspection.

4.7.1.1 <u>Unit of product</u>. A unit of product shall be at least 100 feet of cable of the same type designation.

4.7.1.1.1 <u>Inspection lot</u>. The inspection lot shall consist of the number of units of product, offered for inspection at one time. All of the units of product in the inspection lot submitted shall have been produced during the same production period with the same materials and processes.

4.7.1.1.2 <u>Sample unit</u>. A sample unit shall be a unit of product selected at random from the inspection lot without regard to quality.

4.7.1.1.3 <u>Sample unit size</u>. Unless otherwise specified, the sample unit size shall consist of that number of sample units required by the inspection lot size, as determined by the sampling plans in MIL-STD-105.

4.7.1.1.4 <u>Specimen</u>. A specimen shall be an individual length of cable cut from the sample unit.

4.7.1.2 <u>Group A inspection</u>. Group A inspection shall consist of the examinations and test specified in table A6.

4.7.1.2.1 <u>Sampling plan</u>. Statistical sampling and inspection shall be in accordance with MIL-STD-105 for general inspection level II. The acceptable quality level (AQL) shall be as specified in table A6.

4.7.1.2.2 <u>Rejected lots</u>. If an inspection lot is rejected, the supplier may screen out the defective units, and resubmit for reinspection the good lots using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified.

4.7.1.2.3 <u>Disposition of sample units.</u> Sample units from which a specimen has failed any of the group A inspection tests shall not be delivered on any order, even though the inspection lot submitted is acceptable.

TABLE A6. <u>Group A inspection</u>.

Examination or test	Requirement paragraph	Test paragraph	AQL (% defective)
Visual and mechanical examination	3.6	4.8.1	1
Physical dimensions	3.6	4.8.1	
Marking	3.10	4.8.1	
Workmanship	3.11	4.8.1	

4.7.1.3 Group B inspection. Group B inspection shall consist of the examinations and tests specified in table A7.

4.7.1.4 Sampling plan. Sample units shall be selected from those types covered by a single specification sheet in accordance with table A6 or A7, 3 months after the date of notification of qualification, except when the total production in a 3-month period is less than two units of product (10,000 feet) inspection need not be made until either production is at least 2 units of product or a total of 6 months has elapsed since the inspection was performed in which case only one sample unit shall be tested.

TABLE A7. Group B inspection.

Examination or test	Requirement paragraph	Test paragraph	AQL (% defective)
Impulse test	3.5.1	4.8.9	4
Voltage withstanding	3.5.3	4.8.4	
Corona	3.5.5	4.8.6	
Capacitance	3.5.7	4.8.7	
Stress-crack resistance	3.6.7	4.8.12	
Outer conductor integrity	3.6.8	4.8.13	
Cold bend	3.6.10	4.8.14	
Dimensional stability	3.6.10	4.8.15	
Bendability	3.6.11	4.8.16	

4.7.1.4.1 Sampling plan. The sampling plan shall be in accordance with MIL-STD-105 for special inspection level S-3. The sample size shall be based on the inspection lot size from which the sample was selected for group A inspection. The AQL shall be as shown in table A7.

4.7.1.4.2 Rejected lots. If an inspection lot is rejected, the supplier may screen out the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.7.1.4.3 Disposition of sample units. Sample units from which a specimen has failed any of the group B inspection tests shall not be delivered on any order, even though the inspection lot submitted is accepted.

4.7.3 Inspection of preparation for delivery. The sampling and inspection of the preservation-packaging and internal package marking shall be in accordance with the quality assurance provisions of MIL-C-12000.

4.8 Methods of examination and test. Test parameters given in the following tests are not to be assumed as the cable operating conditions, temperatures or limits. A method to precondition semirigid cable for normal use is suggested in this specification (see 6.5). Methods of examination and test given in the specification shall be the only acceptable methods unless an aternate method has been agreed to by the qualifying authority prior to the performance of the test. The test methods described herein are the preferred methods and shall be the referee method in cases of dispute.

4.8.1 Visual and mechanical examination (see 3.6). The cable shall be examined to verify that the design, construction, physical characteristics and dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.4 and 3.6).

4.8.1.1 Diameter measurements (see 3.6.1). Measurements shall be made on a suitable length (12 inch minimum) of cable taken from the end of the sample unit. Inner components shall be made accessible by stripping and removing the outer components carefully so as not to nick, cut, cold-work, or otherwise damage the component to be measured. Measurement shall be located 3 to 4 inches apart along the specimen length. Measurements shall be made at each point in two mutually perpendicular planes, so that a total of eight measurements are performed on each specimen. Measurements shall be made with a micrometer caliper or any other instrument of equal accuracy. Measurements include:

a) Inner Semicon outside diameter and thickness
b) Primary insulation outside diameter and thickness
c) Outer Semicon outside diameter and thickness
d) Shield outside diameter
e) Jacket outside diameter and thickness

4.8.1.2 Out-of-roundness of jacket measurements (see 3.6.2). The out-of-roundness of the jacket shall be monitored on a continuous production basis, and the jacket diameter shall be as specified (see 3.1). The out-of-roundness measurements shall be permanently recorded with a device capable of producing continuous graphic records. Two recordings shall be made, as nearly simultaneously as possible, of the outside diameter 90° apart and a point in the manufacturing process where further dimensional change will not occur. The recordings shall be permanent and reproducible by a common commercial process. The technique used (including the detector, recorder and associated components) shall have a response capable of recording changes in the diameter with a sensitivity of 0.001 inch along the length of cable at whatever speed the cable is traveling. The strip chart response time shall be compatible with the remainder of the system. The pen traverse shall be large enough to distinguish changes of diameter of 0.001 inch. The chart speed relative to the cable speed shall be such that the recording must be identifiable to within 2 feet of the point on the cable length measured. Each foot of cable shall be represented by no less than 0.05 inch of recording paper.

4.8.1.3 Eccentricity of inner conductors (see 3.6.3).

4.8.1.3.1 Procedure. Four specimens, each 1 inch approximately in length, shall be cut from the end of the sample unit. The outer components of the cable shall be removed down to the dielectric core. The ends of the specimen shall be cut squarely and carefully deburred. The eccentricity, in terms of displacement of length, shall be measured with a machinist's or toolmaker's microscope, or a comparator, or any other instrument capable of yielding a resolution of at least .0001 inch. At spacings approximately 45° apart around the periphery of the inner conductor, measurements shall be taken of the dielectric wall thickness. The thickest measurement (T_{max}) and the thinnest measurement (T_{min}) shall then be used to compute the displacement, using the following formula:

$$\% \text{ Eccentricity} = \frac{T_{max} - T_{min}}{\text{Measured diameter of core}} \times 100$$

The percent eccentricity of the inner conductor shall be within the specified requirements (see 3.1). Measurements shall include:

a) Inner Semicon
b) Primary insulation
c) Outer Semicon
d) Jacket

4.8.1.4 Adhesion of conductors (see 3.6.4).

4.8.1.4.1 Specimen.

(a) Two specimens of each cable shall be cut from the end of the sample unit. Each specimen shall be prepared as shown in Figures A1-A and A1-B. Stripping shall be done carefully. For semirigid cables, no more than 0.250 inch of material shall be removed at one time.

(b) The adhesion to conductors test shall be performed with a tensile tester and a test fixture such as shown in Figures A2-A and A2-B. The diameter of the hole in the test plate shall be such that there is a clearance of .004 $\pm$.001 inch larger than the diameter of the applicable inner conductor or dielectric core. The inner conductor or dielectric core extending through the test plate hole shall be pulled with a constantly increasing force at a rate not to exceed 0.5 inch per minute. Avoid sudden pulls and jerking. Conductor adhesion shall be defined as the highest tensile tester reading obtained when the conductor-to-core bond is broken. In performing this test physical handling of the specimen shall be kept to a minimum to avoid specimen degration. The adhesion to conductor requirement, as noted by the reading on the tensile tester shall not exceed the specified value (see 3.1).

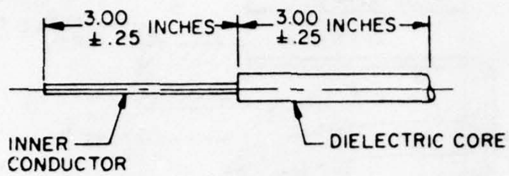


FIGURE A1-A Stripping Dimensions for Flexible Cables.

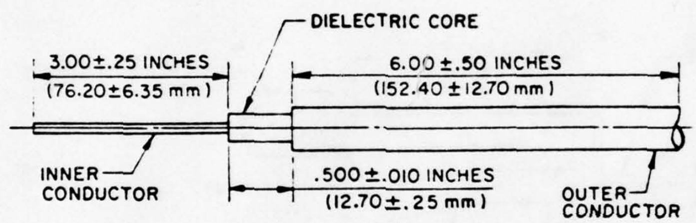


FIGURE A1-B Stripping Dimensions for Semi-rigid cables.

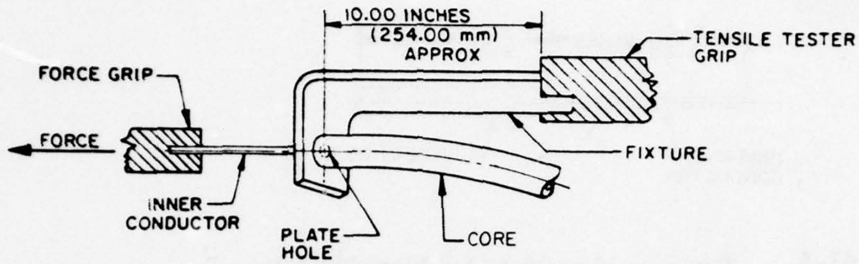


FIGURE 2A: Typical Test Fixture for Use with Flexible Cables.

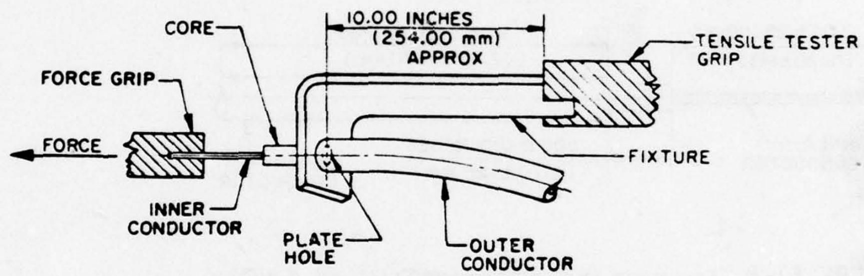


FIGURE A2-B Typical Test Fixture for Use with Semi-rigid Cables.

4.8.2 Continuity (see 3.5.1). To establish continuity, 25 volts dc maximum shall be applied to both ends of each conductor and shield of the cable through an appropriate indicator, such as an ohmmeter, light, or buzzer. The test voltage may be applied to each conductor and each shield individually or in series.

4.8.3 Spark test (see 3.5.2). The specimen shall be tested for jacket spark in accordance with method 6211 per FED-STD-228. A test voltage (see 3.1) at a frequency between 48 and 62 Hz shall be applied between the outermost braid or shield and the outer surface of the jacket.

4.8.4 Voltage withstand. Voltage withstand tests shall be made on all lengths of completed cable.

4.8.4.1 Apparatus. The voltage withstand tests shall be made with alternating potential from a source of ample capacity, but in no case less than 5 kilovolt-ampere, having a frequency not greater than 500 Hz and a wave shape approximately a sine wave under all test conditions. The testing voltage may be measured by means of a voltmeter (rms) connected to voltmeter coil in the high-tension winding of the testing transformer, or to a separate instrument transformer.

4.8.4.2 Procedure. The test voltages and application (conductor to ground, conductor to conductor, shield to shield, and so forth) shall be as required by the specification sheet. The time of application for all voltage withstand tests shall be 1 minute. The initially applied voltage shall be not greater than 600 volts. The rate of increase shall be approximately uniform and not over 100 percent in 10 seconds nor less than 100 percent in 60 seconds. All unarmored cables requiring electrical tests for the jacket shall be immersed in a grounded water bath for at least 1 hour, and tested while still immersed, using the water as the ground.

4.8.4.3 Observation. All cable shall withstand without failure the voltages specified on the specification sheet.

4.8.4.4 Test Voltage. The test voltage shall be 160 percent nominal operating voltage for alternating current cables and 56.5% nominal operating voltage for dc cables for one minute where $V_{DC}peak = 2\frac{1}{\sqrt{2}}V_{ac}$.

4.8.5 Insulation resistance. The insulation resistance shall be determined for conductor insulation and for cable jackets, when required by the specification sheet.

4.8.5.1 Procedure. The test shall be performed on each length of completed cable immediately following the voltage withstand test. The leakage current shall be measured after 1-minute electrification with a direct current potential of not less than 200 nor more than 500 volts. Cables with unshielded conductors shall be tested between conductor and water. Cables with individually shielded conductors shall be tested between conductor and shield. Where cable jackets have insulation resistance requirements, the test shall be made between the overall cable shield and the water bath. The conductor or shield whose insulation is under test shall be connected to the negative terminal of the test equipment and readings shall be taken after 1-minute electrification.

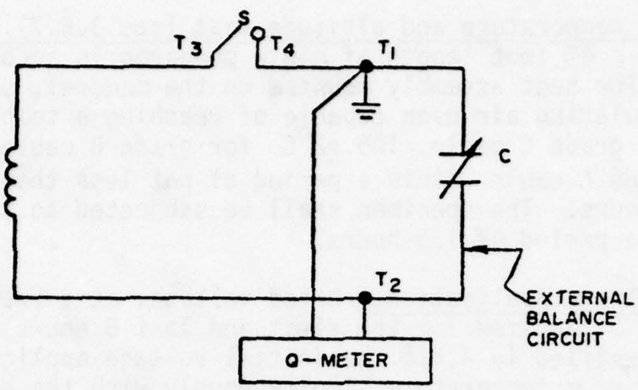
4.8.5.2 Observation. The insulation resistance values at 15.5°C. shall be not less than required by the specification sheet. If the measurement is made at a temperature other than 15.5°C., the manufacturer shall correct the measured value to 15.5°C. If the insulation resistance is equal to or greater than that required, when the measurement is made at a temperature greater than 15.5°C., no correction factor need be employed. The manufacturer shall demonstrate that the correction factor used is accurate for his insulating compound.

4.8.6 Corona Test (see 3.5.5). Two specimens shall be tested in accordance with ASTMD1868, (Circuit, Figure 1). The detector used shall have a sensitivity of less than 1.0 picocoulomb before it is loaded with the test specimen. The detector shall have a uniform frequency response up to 500 kiloherz. The following details shall apply:

(a) Magnitude of test voltage - 110% rated voltage.
(b) Nature of potential-dc.
(c) Duration of application of test voltage - partial discharges shall be measured for 60 minutes after operating voltage is attained. Voltage shall be increased from 0 to operating test voltage at rate of 500 volts per second.
(d) Points of application of test voltage - center conductor to shield.
(e) Examination after test-cables shall be visibly examined for evidence of breakdown, arcing, or other visible damage.
(f) Partial discharges shall not exceed more than one discharge per minute above 10 pc. Partial discharges greater than 50 pc are unacceptable. Partial discharges within the cable shall be calculated per ASTMD1868 or ASTMD3382-75.

4.8.7 Capacitance (see 3.5.6). The cable shall consist of a 10-foot 2-inch length of completed cable with all shields removed for a distance of 1 inch from each end and the insulation removed from a distance of 1/2 inch from each end of all conductors. The length of the specimen shall be the shielded length.

4.8.7.1 Test equipment. A Q-meter and oscillator equipped with the external balance circuit, as shown on figure A3 is recommended. Other equipment may be used where it can be demonstrated that such an alternate will yield equally accurate results.



L: Coil, of inductance suitable for the magnitude of the reactances to be measured.

C: Variable calibrated precision condenser.

T_1 and T_2: Terminals of Q-meter-T_1 grounded.

T_3 and T_4: Terminals in the inductive branch of the balance circuit. (T_4 can be identical with terminal T_1.)

S: Means of connecting T_3 to T_4.

Figure A3 - Test equipment for capacitance test.

The leads from L and C to the Q-meter terminals shall be as short as practicable. The test specimen of leads from the specimen shall be terminated at or as near as possible to the terminals of L.

4.8.7.2 Procedure. The shield at each end of the conductor under test shall be grounded. Measurements shall be made for each shielded conductor using the frequency required by the specification sheet. Proceed as follows for each conductor of the specimen:

(a) Connect terminal T_3 to T_4.

(b) Balance the circuit to resonance (maximum reading on the Q-meter) by adjusting C. Designate this reading of C as C_0.

(c) Connect the conductor to terminal T_2 and the shield to terminal T_1.
Balance the circuit by adjusting C to a new value. Designate this value as C_1.

4.8.7.2.1 Calculation. The capacitance (C) per foot, for each conductor, shall be determined by the formula:

$$C = \frac{(C_0 - C_1)}{(\text{length of specimen in feet})}$$

4.8.8 High temperature and altitude test (see 3.5.7). The cable shall consist of a 4½ foot length of cable prepared in accordance with figure A4. The test assembly mounted on the mandrel, shall be placed in a circulating air oven capable of reaching a temperature of 200 $\pm 2^\circ$C. for grade C cable, 105 $\pm 2^\circ$C. for grade B cable, and 85 $\pm 2^\circ$C. for grade A cable within a period of not less than 1 hour or more than 3 hours. The specimen shall be subjected to this temperature for a period of 125 hours.

4.8.8.1 Voltage application. Rated voltage, at a frequency of 60 c.p.s., shall be applied for the first and last 5 hours of the 125 hour test specified in 4.8.8.The initial voltage application shall be made at room temperature simultaneously with the start of the oven heating units. At the conclusion of this test, the insulation, braid, and sheath shall be examined for damage that might affect subsequent performance.

4.8.8.2 Altitude. At the conclusion of the voltage application test specified in 4.8.8.1, the test specimen, as set up in figure A4 shall be placed in an altitude chamber and the pressure therein shall be reduced to the equivalent at 70,000 feet ± 5,000 feet altitude, and maintained within these limits for the voltage application test specified in 4.8.8.2.1. **The cable shall pass corona at altitude as specified in 4.8.6.**

4.8.8.2.1 Voltage application. Rated voltage, at a frequency of 60 c.p.s., shall be applied between the cable conductor and the conduit assembly as shown on figure A4 for a period of 2 hours. The specimen shall then be inspected for evidence of insulation rupture, cracking or other damage.

4.8.9 Impulse voltage test (see 3.5.8). The cable shall be tested with a basic insulation level surge voltage (BIL) according to the AIEE-EEI-NEMA Standard Basic Insulation Levels, NEMA Publication No. 109, dated January 1941 to the value shown in table XVI. The BIL shall be in accordance with the following definition:

> "Basic impulse insulation levels are reference levels expressed as impulse crest voltage with a standard wave not longer than 1½ x 40 microseconds (1½ microseconds rise and 40 microseconds decay, Figure A5). Apparatus insulation as demonstrated by suitable tests shall have capability equal to, or greater than, the basic insulation level."

The BIL levels upon which the capacitors shall be tested are given in table A8.

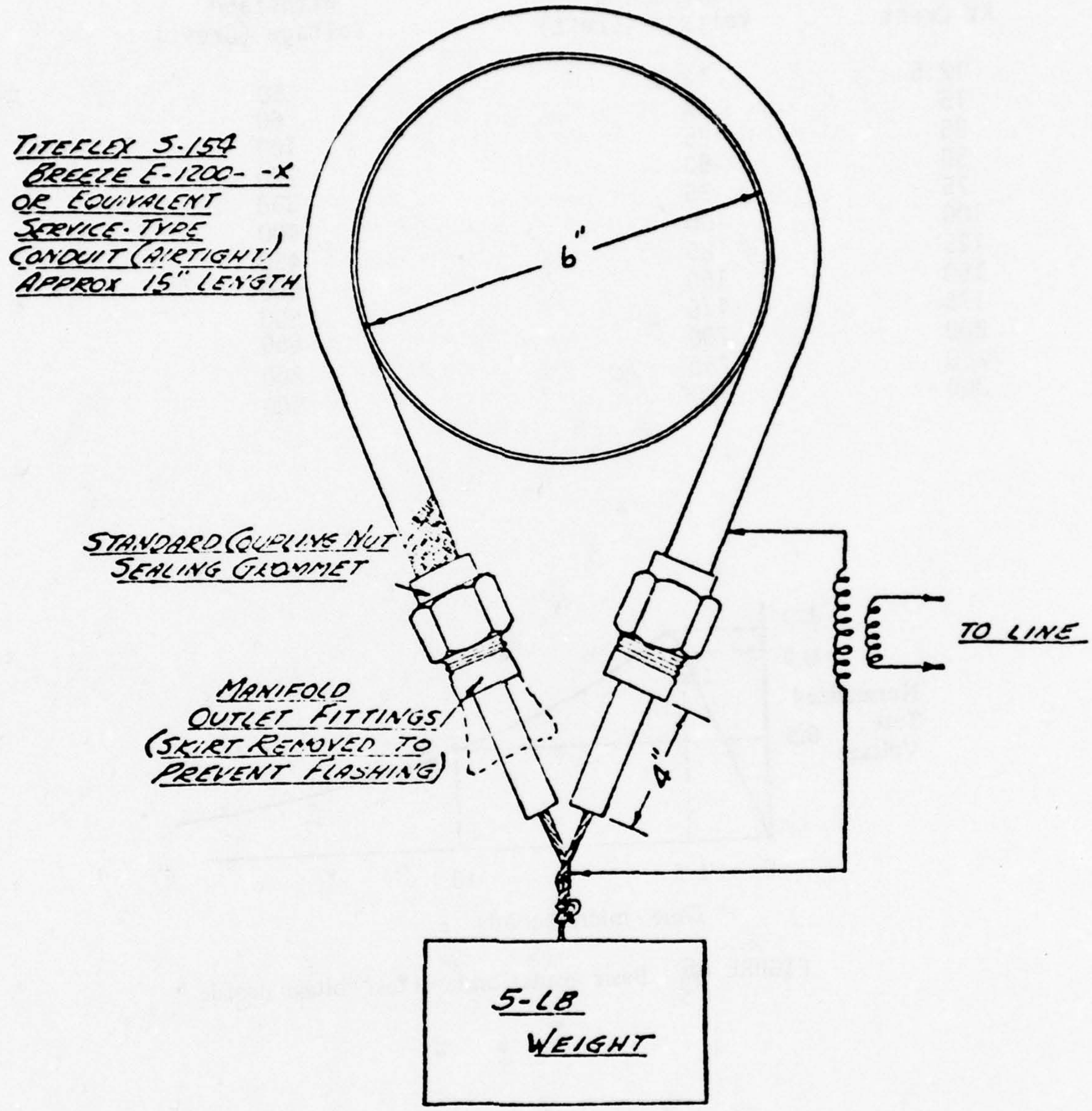


FIGURE A4 HIGH TEMPERATURE AND ALTITUDE TEST SETUP (Par. 4.8.8).

TABLE A8 Basic insulation level voltages.

Voltage Rating KV Crest	Maximum Operating Voltage (Crest)	Impulse Withstand Voltage (Crest)
12.5	12.5	50
15	15	60
25	25	100
50	50	200
75	75	300
100	100	400
125	125	450
150	150	550
175	175	600
200	200	650
250	250	800
300	300	900

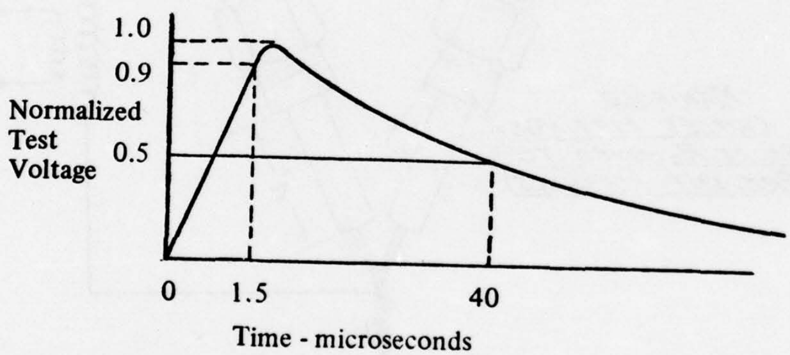


FIGURE A5 Basic insulation level test voltage profile

4.8.10 Mechanically induced noise voltage (See 3.6.5).

4.8.10.1 Procedure. The mechanically induced noise voltage (see figure A6) shall be measured by swinging a weight from a specimen that has a catenary configuration that shall be formed by supporting a 5-foot specimen in a 4-foot span. All the clamps shall be of a circumferential compression type. A 9-foot specimen shall be prepared for testing as follows: Remove 2 inches of the jacket from one end of the cable, leaving the outer braid intact; push the braid back and cut off one inch of the dielectric core and the inner conductor; insulate this open end of core and conductor with electrical tape and insulation sleeving; pull the braid back down over this insulated core and conductor, twist and solder the braid to form an interference shield; set this end in the clamp on one post with the interference shield just sticking out of the clamp; measuring off 5 feet of cable, set the cable into the other clamp on the outer post. At the end of the overhang attach an applicable connector. This connector will be used to connect the specimen to the measuring equipment. The weight used shall be 40 pounds per square inch of cross-sectional area of the cable. The weight on the cable shall be held tautly at its center point by a clamp in the same horizontal plane as the cable supports. The oscilloscope sweep shall be started prior to the release of the weight. At least 8 seconds of cable swings shall be recorded on the trace. The noise voltage induced by the swing shall be taken as the peak-to-peak voltage and shall not exceed the specified value (see 3.6.5).

4.8.10.2 Measurement. An oscilloscope and camera, or storage oscilloscope may be used to record the generated noise of the system. The specimen shall be connected directly to the amplifier. The amplifier shall have a 10 megohm minimum input impedance and the sensitivity of the amplifier shall be 10 microvolts per centimeter. The shunt capacitance (including the specimen capacitance) and the band width shall be as specified in the detailed requirements. The sweep speed shall be 1 centimeter per second.

4.8.11 Aging stability (see 3.6.7). Two specimens shall be cut from the sample unit. For cables whose nominal jacket diameter is 0.5 inch or larger, the specimen length shall be 95 ± 1 feet times the cable diameter, but not to exceed 100 ± 1 feet.

4.8.11.2 Procedure. The specimen shall be suspended in a heat chamber without touching one another or the walls of the chamber and conditioned for 7 days at the applicable test temperature in table A9. Test temperatures for cable jacket types not listed in table A9 shall be as specified (see 3.6.6). Heated air shall be circulated so as to maintain a uniform test temperature. After the conditioning period, the specimens shall be removed from the heat chamber and conditioned at room ambient temperature for 4 hours minimum.

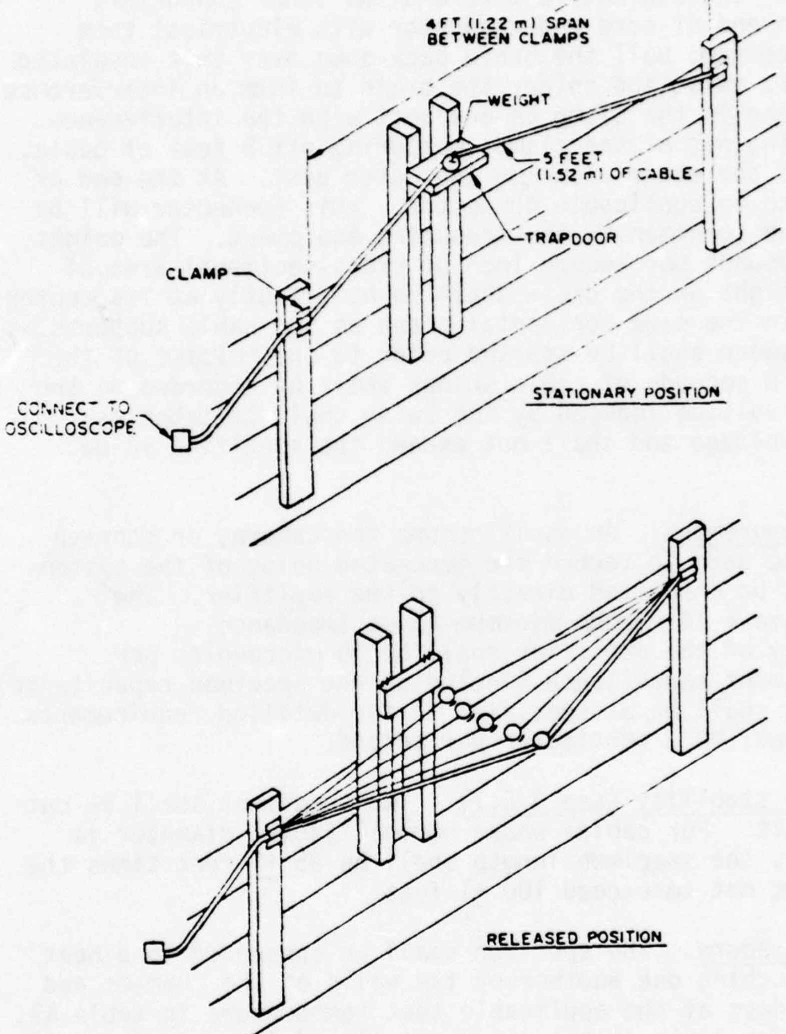


FIGURE A6 TYPICAL MECHANICAL RELEASE FIXTURE

4.8.11.2 Procedure (continued)

(a) Examine the specimen for cracks, flaws or other damage in the jacket material. For marked cables, examine the marking for legibility.

(b) Following the test, the specimen shall be subjected to the cold bend test (see 4.8.14).

TABLE A9 Jacket test temperatures.

Jacket types	°C Temperature
Grade A	+85 ± 2
Grade B	+105 ± 2
Grade C	+200 ± 2

4.8.12 Stress-crack resistance (see 3.6.8). Two specimens, approximately 3 feet long, shall be cut from the sample unit for test.

4.8.12.2 Procedures. Clamp one end of each specimen to a mandrel whose diameter is three times the nominal jacket diameter of the cable. Wrap each specimen for 10 turns around the mandrel and clamp the specimen to the mandrel at this point. The specimens shall be suspended in a heat chamber without touching one another or the walls of the chamber and conditioned for 96 hours minimum at the temperatures listed in table A9. Heated air shall be circulated so as to maintain a uniform test temperature. After the conditioning period, the specimen shall be removed from the heat chamber and conditioned at room ambient temperature for 4 hours minimum.

(a) Examine the specimen for cracks, flaws or other damage in the jacket material. For marked cables, examine the marking for legibility.

(b) Unwind the specimen from the mandrel and examine for cracks, flaws, or other damage in the jacket material. For marked cables, examine the marking for legibility.

(c) After the stress-crack resistance test, the specimen shall be subjected to the cold bend test (see 4.8.14).

4.8.13 Outer conductor integrity (see 3.6.9). Two specimens, approximately 2 feet long, shall be cut from the sample unit. The specimens shall be suspended in a heat chamber without touching one another or the walls of the chamber and conditioned for 1½ hours minimum at the specified test temperature (see 3.1). Heated air shall be circulated so as to maintain a uniform test temperature. After the conditioning period, the specimens shall be removed from the heat chamber and conditioned at room ambient temperature for 4 hours minimum. Examine the specimens for cracks, flaws, or other damage in the outer conductor material.

4.8.14 Cold bend (see 3.6.10). Two specimens shall be cut from the sample unit. The specimen lengths shall be the same as for the aging stability, stress-crack resistance and other outer conductor integrity tests, as applicable (see 4.1.11, 4.1.12 and 4.8.13).

4.6.14.1 Procedure.

(a) Specimens shall be tested in either a straight length, or in a loosely wrapped coil having a diameter of not less than 12 inches.
(b) Place the specimens in a cold chamber and condition them for 20 hours minimum at $-65^{\circ}C \pm 2^{\circ}C$.
(c) After the conditioning period, remove the specimens from the cold chamber and immediately wrap them four full, close turns around a mandrel whose diameter is 10 times the nominal outside diameter of the specimen, and then subject them to the voltage withstanding test (see 4.8.4).

Unwind the specimen from the mandrel and, except at the clamping points, examine for cracks, flaws or other damage in the outer surface material.

4.8.15 Dimensional stability (see 3.6.11). A 5-foot minimum specimen shall be cut from the sample unit. The ends of the specimen shall be cut squarely and carefully deburred. The specimen shall be placed in a heat chamber, coiled or straight, and conditioned for 6 hours minimum at the applicable test temperature shown in table A9 Heated air shall be circulated so as to maintain a uniform test temperature. After the conditioning period, the specimen shall be removed from the heat chamber and conditioned at room ambient temperature for 4 hours minimum. Measure both ends of the specimen for protrusion or contraction of the inner conductor. The measurement at each end shall not exceed the specified value (see 3.7.14 and 3.1).

4.8.16 Bendability (semirigid, see 3.6.12). Two specimens, each approximately 1 foot long, shall be cut from the sample unit. The middle section of the specimen shall be formed for two complete turns around a mandrel of specified diameter (see 3.1). (Although no special tools are needed to guide the cable as it coils around the mandrel, a mechanism may be provided so as to avoid any damage to the outer conductor.) Remove the coiled specimen from the mandrel and examine the outer surface for cracks, splits, fracturing, wrinkling or other damage.

4.8.17. Flammability (see 3.6.13). The test specimen shall consist of a 20 inch length of cable.

4.8.17.1 Apparatus. The testing apparatus shall consist of a Bunsen burner having a ¼ inch inlet, a nominal bore of 3/8 inch, a length of approximately 4 inches above the primary inlets, and equipped with a wing-top flame spreader having a 1/16 by 2 inch opening fitted to the top of the burner.

4.8.17.2 Preparation. The specimen shall be suspended taut in a horizontal position within a partial enclosure which will allow a flow of air sufficient for complete combustion but which will be free from drafts.

4.8.17.3 Procedure. The tip of a 2 inch gas flame, with an inner-cone one-third its height, shall be applied to the center of the length of cable. The flame shall be applied for 15 seconds, after which time the cable shall be observed for evidence of separation or burning particles, and the rate of travel of the flame along the cable shall be determined.

4.8.18. Fungus resistance (see 3.6.14). The test specimen shall consist of a length of cable, 4 feet long.

4.8.18.1 Procedure. The test shall be conducted in accordance with the applicable provisions of Specification MIL-F-13927 except that no performance test will be conducted during exposure. At the end of the 90 day test, each specimen shall be subjected to the test specified in 4.8.4 to determine conformance to 3.6.14.

4.8.19 Anti-icing fluid resistance (see 3.6.15). The test specimen shall consist of a 4 foot length of completed cable.

4.8.19.1 Preparation. The specimen shall be wound on a mandrel in the same manner specified for the bendability test specified in 4.8.16.

4.8.19.2 Immersion. The specimen, as thus wound on the mandrel with metal test sleeve in position, shall be immersed for 18 hours in anti-icing fluid (50 percent alcohol, 50 percent water) at room temperature, with not less than 3 inches of each end protruding above the surface. Anti-icing fluid used for testing shall conform to Federal Specification O-E-7060. After immersion, specimen shall be removed and drained for 30 minutes and subsequently tested in accordance with 4.8.4 to determine conformance to 3.6.15.

4.8.20 Ozone. Unless certification is provided, cables shall be tested in accordance with ASTM D470 using an ozone concentration of 100 to 150 parts per million (see 3.1 and 3.5.9).

4.8.21 Electromagnetic compatibility. The cable shall meet requirements of RE02 and RE04 tests of MIL-STD-461A. When the cable is subjected to the pulse voltage (rated voltage only) of 4.8.9 or an equivalent sine wave. The sine wave shall include 100 Hz, 400 Hz, 1000 Hz, 10KHz, 100KHz, 1MHz, 10MHz and 20MHz. The requirements of 3.5.10 shall be met.

5. PREPARATION FOR DELIVERY

5.1 Preservation-packaging. Preservation-packaging shall be in accordance with MIL-C-12000, unless otherwise specified (see 6.1). The drum diameter of the unit package (reel or spool types) shall not

5.1 Preservation-packaging (continued) be less than 20 times the nominal outside diameter of the cable. In any case, the drum diameter shall be large enough to preclude the flattening of the cable and to prevent damage to the cable from reeling and unreeling. The number of cable lengths on a reel shall be kept to a minimum consistent with good manufacturing practice. Only identical type designation cable lengths shall be contained in any one package unit. For inspection purposes, the ends of all cable lengths on the package shall be brought out from the package and secured. The center conductor shall be tied to the shield. The ends of all cable lengths shall be moisture-proof sealed in accordance with MIL-C-12000. Reels or spools shall be of a disposable, non-returnable type.

5.2 Packing. Packing shall be in accordance with MIL-C-12000. Exterior shipping containers shall contain equal quantities of identical items to the greatest extent possible.

5.3 Marking. In addition to any required special marking (see 6.2), the unit packages and shipping containers shall be marked in accordance with MIL-STD-129. Marking shall include the date of manufacture. Where paper labels are used containing shipment marking information, the labels shall be protected by a transparent compound to prevent deterioration of the markings. The marking on each unit package, reel or spool, shall be located on the flange area whenever possible and shall be applied in such a manner designed to preclude the possibility of the marking becoming illegible during its use. Each unit package, reel or spool, shall be marked with the date of manufacture, total length of cable in the unit package, with the length of each piece in the order wound. The following warning note shall be marked on each unit package:

WARNING: KEEP ENDS SEALED: MOISTURE DAMAGES CABLE: STORE IN COOL, DRY LOCATION.

6. NOTES

6.1 Ordering data. Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Title, number and date of the applicable specification sheet.
(c) Complete cable part number (see 1.2.1).
(d) Applicable marking and level of preservation-packaging and packing, if other than specified in section 5. Specify desired continuous length and for semirigid cable, whether cable is to be supplied in straight sections or coils.

6.2 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in applicable qualified products list (QPL) whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification.

6.3 Definitions.

6.3.1 Maximum continuous working voltage. The maximum continuous working voltage is that safe voltage that can be continuously applied to a cable.

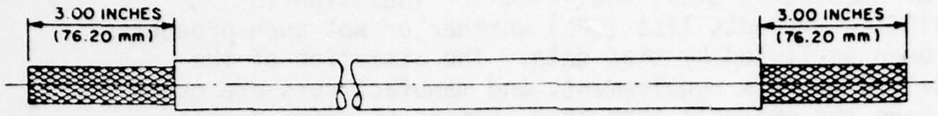
6.3.2 Connectors. The applicable connector series are constructed particularly for these cables. Extreme care shall be taken in handling a coaxial cable for assembly to connectors so as not to work-harden, overheat, or damage the cable components.

6.3.3 Minimum recommended bend mandrel radius for normal use. The minimum recommended bend radius for a cable in normal usage is given on the specification sheet. The radius given is to the outer surface of the cable. This minimum bend radius is dependent upon the material of the outer conductor and its thickness. Do not use tight bend radii unless the application warrants it. Extreme care should be taken in the forming to prevent wrinking or cracking.

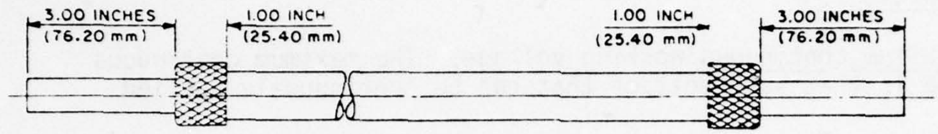
6.3.4 Operating temperature range. The operating temperature range is the limits between which a cable may be operated continuously without any loss in the basic properties of the cable. This includes the ambient temperature plus the increased temperature due to inner conductor operation. This temperature range is just a guideline, since the mechanical, environmental and electrical requirements of the application contribute to the allowable temperature range. In no case should the testing temperatures be considered as the operating temperature range. Testing is usually done under accelerated conditions so as to possibly degrade the materials.

6.4 Suggested method for making cable ends corona-free is shown in figure A7.

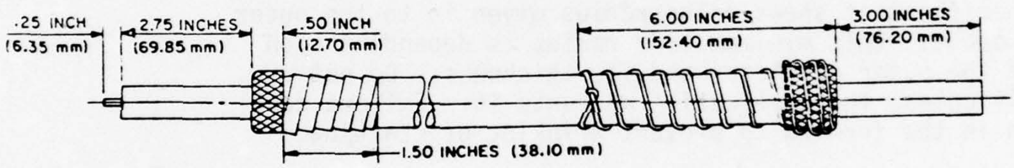
Step 1: Suggested length of cable specimen is 36.00 inches (914.40 mm)



Step 2: Remove 3.00 inches (76.20 mm) of jacket material from each end.



Step 3: Roll back the braid over the jacket and trim as shown. Be careful to avoid breaking any strands. Trim the braid edges neatly to 1.00 inch (25.40 mm) lengths.



Step 4: Trim one end of the specimen to the diamensions shown and cover the braid edge and jacket with a plastic tape as shown. Wrap an AWG No. 20 copper grounding wire tightly over the braid.

FIGURE A7. Suggested method for making cable ends corona free.

APPENDIX

PROCEDURE FOR GROUP QUALIFICATION INSPECTION

10. SCOPE

10.1 This appendix details the procedure for group qualification inspection of cables covered by this specification. The procedure for extending qualification of the required sample to other cables covered by this specification is also outlined herein.

20. EXTENT OF QUALIFICATION

20.1 Group Qualification. The cable types listed in table A10 are eligible for group qualification. The groups are based on similar characteristics and requirements. At the discretion of the Government, qualification may be extended to cover any or all cable types in a group, based on compliance of one cable type in that group with the qualification inspection. The Government reserves the right to authorize performance of any or all qualification inspection on additional types in the group that are considered necessary to the extension of qualification within each group. Cable types not included in these groups are not eligible for group qualification.

TABLE A10. Group Qualification.

Group	Submission and qualification of any of the following cable types	Qualifies the following cable types
1	TBD	TBD

APPENDIX B

CABLE ASSEMBLIES

HIGH VOLTAGE CABLE ASSEMBLY CRITERIA DOCUMENT

1. SCOPE

1.1 This specification covers high voltage,power cable assemblies with shielded conductors and connectors for interconnecting high voltage, high power limited life (1750 hours) electrical and electronic assemblies.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein:

SPECIFICATIONS

Federal

T-T-881	Twine, Cotton, Seine
QQ-P-416	Plating, Cadmium (Electrodeposited)
QQ-S-763	Steel Bars, Wire, Shapes, and Forgings, Corrosion Resisting
RR-C-271	Chains and Attachments, Welded, Weldless, and Roller Chain

Military

MIL-B-121	Marking for Shipment and Storage
MIL-I-3930	Insulating and Jacketing Compounds, Electrical (for Cables, Cords, and Wires)
MIL-I-7798	Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic.

STANDARDS

Federal

FED. TEST METHOD STD. No. 601	Rubber: Sampling and Testing

2.1 (Continued)

STANDARDS

Military

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-108	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-810	Test Methods for Electronic and Electric Component Parts
MIL-STD-1285	Marking of Electrical and Electronic Parts

(Copies of specifications and standards required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

NEMA Publication No. 109	AIEE-EEI-NEMA Standard Basic Insulation Level
ASTM D470	Testing of Rubber and Thermoplastic Insulated Wire and Cable
ASTM D1868	Detection and Measurement of Discharge (Corona) Pulses in Evaluation of Insulation Systems

2.1 (Continued)

ASTM D3382-75	Measurement of Energy and Integrated Charge Transfer Due to Partial Discharges (Corona) Using Bridge Techniques.
Capacitors Criteria Document	Appendix C
Cable Criteria Document	Appendix A

NATIONAL MOTOR FREIGHT TRAFFIC ASSOCIATION, INC., AGENT

National Motor Freight Classification
(Applications for copies should be addressed to the American Trucking Associations, Inc., ATTN: Tariff Order Section, 1616 P Street NW, Washington, D.C. 20036.

3. REQUIREMENTS

3.1 Detail requirements. Detail requirements or exceptions to the general requirements specified herein shall be as specified by the specification sheet. In the event of any conflict between the general requirements of this specification and the specific sheet, the latter shall govern.

3.2 Qualification. Cables furnished under this specification shall be products which have been tested and passed the qualification tests listed herein.

3.2.1 Requalification. Changes in materials and constructions shall require the written approval of the cognizant government procurement agency. Incorporation of any changes which have not been so approved shall require requalification of the cable or groups of cables in question.

3.3 Description. Cable assemblies shall consist of cables, connectors, dummy connectors, adapters, and terminal lugs and caps. Dimensions and tolerances shall be shown on the detailed specification sheet where required. Where tolerances are not shown or where those prescribed could result in incorrect fits, the supplier is responsible for providing tolerances to insure correct fit, assembly, and operation of each assembly. No deviation from dimensions or tolerances shown on the detailed specification sheet is permissible without prior approval of the contracting officer.

3.3.1 Materials. The material for each part of the cable assembly shall be as specified (see 3.1). When a definite material is not specified, a material which will enable the element to meet the requirements of this specification shall be used. Acceptance or approval of a constituent material shall not be construed as a guarantee of the acceptance of the finished product. Materials shall conform but not be limited to the materials specified for high voltage cables and for high voltage connectors as specified

3.3.1 (Continued)

in the High Voltage Cable criteria document and the High Voltage Connector criteria document.

3.4 Construction. The cables shall be so constructed that repeated bending in any installed position will not be unduly harmful to them. Strain relief sleeves shall be provided to relieve the bending stress on the cables where necessary in their installed position. These strain relief sleeves shall be provided with proper fastening devices. The sleeves shall prevent bending of the cable to a radius of less than 4 times the cable diameter.

3.4.1 Cable body. The cable body shall consist of a shielded single conductor core. The single conductor may consist of two or more separate uninsulated conductors whose ends shall be joined together before final assembly to form a single effective conductor. The cable shall have the following coverings in the order indicated, with the last covering on the outside:

Semiconductor compound
Insulation
Semiconductor compound
Braid
Jacket insulation

The copper braid shall be grounded by means of the connector shell. The outer layer of semiconductor compound shall be treated as a conductor and shall not extend beyond the cylindrical section of the metal stress cone in the terminals.

3.4.2 Cable terminals. Each cable shall be terminated with plugs for insertion into high voltage connector receptacles of high voltage transformers or electrical/electronic equipment. The high voltage cable assemblies

3.4.2 (Continued)

shall be so arranged as to permit their use as either a cathode or anode cable assembly and to permit their terminating plugs to be used interchangeably in the high voltage transformer and other high voltage assembly housings, length permitting.

3.4.2.1 Plug. The plug mating face shall be a resilient semi-flexible material within a Shore A Durometer range of 35 to 85. The plug shall be a part of the cable assembly and the material used for insulation shall be the same as the cable to which the connector is to be bonded. The insulation shall fully enclose the base of the socket. The cable and connector insulation shall be molded integrally without cracks or voids with a seal to the socket and interconnecting wire core. See Connector Criteria Document, Appendix D.

3.4.3 Receptacles. A receptacle shall be a unit which is fixed on either the aircraft or electrical/electronic assembly. The molded insert shall have one male contact and shall be molded into the steel shell. No voids or cracks shall exist between the molded insert and male contact or between the molded insert and steel shell. See Connector Criteria Document, Appendix D.

3.4.4 Shells and coupling rings. Shells and coupling rings shall be made of nonmagnetic corrosion-resisting steel in accordance with QQ-S-763, 300 series classes.

3.4.4.1 Finish. The resultant finish on all connectors shall be electrically conductive. The finish of connectors with corrosion-resistant materials, shells and coupling rings, such as aluminum shall be cadmium plated in accordance with QQ-P-416, Type 2, Class 3, color-black. All other corrosion-resisting steel connectors shall be passivated, External screws may be stainless steel in lieu of the finish specified.

3.4.5 Dummy connectors. Dummy connectors shall be molded from the same type insulation material conforming to MIL-I-3930 qualified connector material.

3.4.5 (Continued)

Dummy connectors shall prevent the entrance of moisture, dirt, or other foreign material into the specified plug or receptacle.

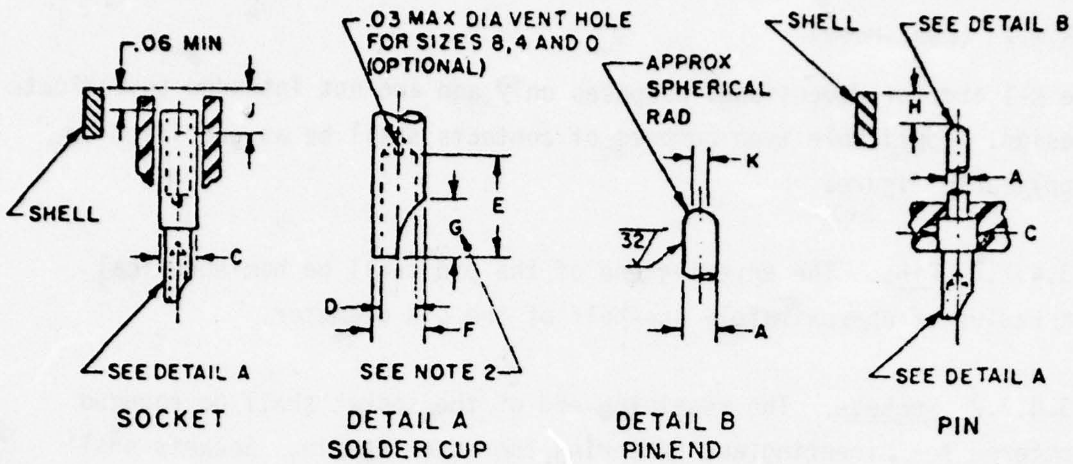
3.4.5.1 Attaching means. Dummies shall be attached to the cable by either a length of cotton twine or a brass chain as specified on the applicable specification sheet.

3.4.5.1.1 Cotton twine. Cotton twine shall conform to T-T-881, No. 18, and shall be attached to the dummy and cable assembly by means of a durable knot which will not slip when pulled.

3.4.5.1.2 Chain. Chain shall conform to RR-C-271, type II, class 6, (safety chain); nominal metal thickness 0.023 inch; approximately 24 links per foot; and minimum tensile strength of 110 pounds.

3.4.6 Caps. A watertight "dummy" cap shall be placed on each plug and each receptacle for protection during shipment and installation. The cap shall consist of a rubber plug or receptacle made of jacket material conforming to MIL-I-3930 and shall be designed to protect the mating surfaces of the connector from moisture and dirt. Tape shall be wrapped over the joining seam to hold the cap securely in place and to give additional protection from moisture and dirt. The tape shall conform to MIL-I-7798 and shall be 0.007 inch thick and 0.75 inch wide. The cap shall not damage or deform the connector in any way. Each cap shall have a male socket (plug end) or female socket (receptable end) shorted to the metal coupling ring. This shorting bar is to protect personnel from hazardous charge buildup during shipping and storage.

3.4.7 Pins and sockets. Pins and sockets of the molded connectors, inserts, and adapters shall be centered, anchored, and molded perpendicular to the face of the component so that they will not loosen by repeated connection and disconnection with other electrical connectors. There shall be no intrusion of insulation or foreign material into the socket. Contact dimensions shall be as specified in Figure B-1. The illustration shown on



Contact size	A 1/ ±.001 Dia	C 2/ Max Dia	D Min Dia	E +.063 -.000	F Dia Min	F Dia Max	H Plug & rcpt Min	H Plug & rcpt Max	J 3/ Max plug and rcpt	K Dia of flat
16	.0625	.127	.069	.250	.096	.116	.250	.312	.281	.032 Max
4/ 16S	.0625	.127	.069	.250	.096	.116	.062	.125	.281	.032 Max
12	.094	.190	.112	.375	.130	.150	.062	.125	.375	.032 Max
8	.142	.310	.205	.500	.243	.259	.062	.125	.375	.032 Max
4	.225	.441	.328	.625	.370	.397	.062	.125	.375	.105 ±.021
0	.357	.597	.464	.625	.510	.550	.062	.125	.281	.237 ±.021

1/ Applies after plating.
2/ Used for calculating mechanical spacing between contacts and between contacts and shell.
3/ Represents the distance from the end of the shell to the point at which the mating pin engages the socket contact spring.
4/ Dimensions shown are typical for shell sizes 8S, 10S, 10SL, 12S, 14S and 16S.

NOTES:
1. Dimensions are in inches.
2. Sizes 12 and 16: G max = 2/3 E, radius of cutout optional.
   Sizes 0, 4, and 8: Cutout optional.

FIGURE B-1. Solder contact (pin and socket) configuration

3.4.7 (Continued)

figure B-1 are for dimensional purposes only and are not intended to indicate the design. Applicable type numbers of contacts shall be as specified on the applicable figure.

3.4.7.1 Pins. The entering end of the pin shall be hemispherical with a radius of approximately one-half of the pin diameter.

3.4.7.2 Sockets. The receiving end of the socket shall be rounded or chamfered for directing and centering the entering pin. Sockets shall have three slots 0.02 inch maximum width and approximately 120 degrees apart and shall have circumferential-type retaining springs for maintaining positive electrical contact between pin and socket. Sockets shall have an external metallic retaining sleeve or band to prevent distortion of the socket.

3.4.8 Coupling connections. Threaded coupling rings shall be knurled, and designed so that the pin and socket contacts shall engage or disengage as the ring is respectively tightened or loosened. The coupling rings of connector plugs shall be captive to the shell. The coupling rings shall have spanner wrench fittings. Torqueing shall be as specified in the detailed specification.

3.4.8.1 Safety of coupling rings. All threaded coupling rings shall be designed for safety wiring. At least two holes shall be provided for shell sizes 14 and smaller, and at least three equally spaced holes for connector sizes 16 and larger. These holes shall be of a diameter sufficient to accommodate 0.032 inch diameter wire.

3.4.8.2 Engagement seal. Connectors shall contain sealing means so that engaged connectors comply with the requirements specified herein.

3.4.8.2 (Continued)

The design of the seal shall be such that in mated connectors all air paths between adjacent contacts and between contacts and shells are eliminated. There shall be interfacial mating of the engaged connector insert to provide dielectric under compression of 0.010 per inch length insert minimum. Connector plus shells with threaded coupling rings shall be provided with a static peripheral seal to ensure shell to shell sealing.

3.4.8.3 Lubrication. If required by the manufacturer, there shall be provided a cable assembly connector lubricating compound. There shall be complete instructions for the application of this lubricating material to the high voltage connector plugs and inserts.

3.5 Bond between connectors and cables. The bond between a connector or insert and a cable shall withstand the pull specified on the applicable specification sheet for 1 minute without mechanical or electrical damage.

3.6 Degree of closure. Molded connectors, adapters, inserts, caps, and dummy connectors when mated with applicable mating components shall provide a watertight joint as defined in MIL-STD-108.

3.7 Disengagement. The axial tension required to separate the plug shell from a receptacle shall be 12 pounds maximum when tested in accordance with 4.3.1. A thin film insulating grease may be used to lubricate the plug surface.

3.8 Electrical operational requirements. Unless otherwise specified (see 3.1), the electrical operational requirements shall be as specified herein.

3.8.1 Continuity. When cable assemblies are tested as specified in 4.6.4.1, each conductor and shield shall be continuous.

3.8.2 Insulation resistance. The insulation resistance at $25^{o}C$ ($77^{o}F$) shall be greater than 500 megohms when tested in accordance with 4.6.4.2.

3.8.3 Dielectric withstanding voltage. Cable assemblies shall show no evidence of breakdown or flashover when subjected to the test voltages and altitudes in accordance with 4.6.4.3. Corona shall not be considered as breakdown.

3.8.4 Corona. Cable assemblies shall show no evidence of material deterioration or damage when subjected to the test voltages and altitudes in accordance with 4.6.4.4.

3.8.5 Impulse test. When cable assemblies are tested as specified in 4.6.4.5, there shall be no momentary or intermittent arcing or other indication of flashover or breakdown, nor shall there by any evidence of damage.

3.8.6 Ozone. All internal and external materials shall be resistant to ozone. The manufacturer shall certify that all materials are ozone resistant or shall perform the tests specified in 4.6.4.6. There shall be no evidence of ozone damage to the external surface of the cable assembly.

3.8.7 Electromagnetic compatibility. When cable assemblies are tested as specified in 4.6.4.7, the cable assembly shall have a shielding effectiveness of 15 dB minimum, and electrical field effectiveness of **45 dB minimum.**

3.8.8 Operating voltage. The cable assembly shall have an operating voltage as specified in the detailed specification sheet for a period of 1,750 hours without any evidence of electrical or mechanical malfunction. The temperature conditions shall be $-55^{o}C$ to $+85^{o}C$.

3.8.9 Operating current. The operating current shall be as specified in the detailed specification sheet. Peak currents of 50 times operating current shall not exceed a duration of 100 microseconds, 0.04 duty (2 times average operating current).

3.8.10 Fault current. The cable assembly shall meet a fault current of 5,000 times average operating current for a maximum period of 5 microseconds, decaying to 0 amperes in less than 50 microseconds.

3.9 Physical operational requirements. All physical operational requirements of the completed cable assembly shall be as required by the specification sheet.

3.9.1 Diameter measurements. When cable assemblies are examined as specified in 4.3.1, the diameter measurements shall be as specified (see 3.1).

3.9.2 Out-of roundness of jacket measurements (when specified, see 3.1). When cable assemblies are examined as specified in 4.3.1, the out-of roundness of the jacket diameter dimensions shall be as specified (see 3.1).

3.9.3 Eccentricity of inner conductor. When cable assemblies are examined as specified in 4.3.1, the connector pins and socket shall be centrally positioned in the plug (socket) and receptacle (pin), unless otherwise specified (see 3.1).

3.10 Environmental. Unless otherwise specified, the electrical and mechanical characteristic shall remain within specified tolerances before, during and after cable assemblies are exposed to the following environmental conditions.

3.10.1 Random vibration. When tested as specified in 4.6.5.1, a current discontinuity of 1 microsecond or more, disengagement of the mated connectors, evidence of cracking, breaking, or loosening of parts shall be cause for rejection of the cable assembly.

3.10.2 <u>Temperature</u>. There shall be no evidence of damage detrimental to the operation of the cable assembly after being subjected to the temperature extremes in accordance with 4.6.5.2.

3.10.3 <u>Moisture resistance</u>. Cable assemblies shall maintain an insulation resistance of 100 megohms or greater at 25^{o}C after being subjected to the moisture resistance test in accordance with 4.6.5.2.

3.10.4 <u>Salt atmosphere</u>. When tested as specified in paragraph 4.6.5.3, the cable assemblies shall have no degradation of electrical or mechanical performance or deterioration of the ability to mate and unmate the connector-cable assembly. There shall be no evidence of corrosion of bare metals or plating materials.

3.10.5 <u>Altitude</u>. When tested as specified in 4.6.5.4, the cable assemblies shall meet the corona and voltage breakdown requirement of 4.6.4.4. Any evidence of dielectric breakdown or flashover shall be cause for rejection.

3.10.6 <u>Bonding</u>. The electrical fittings shall withstand the bonding test as applicable (See Figure B2 and Figure B3), as specified in 4.6.5.5.

3.11 <u>Marking</u>. Cable assemblies shall be marked with the part number, military specification number, manufacturer's code symbol and name, in accordance with the basic requirements of MIL-STD-1285. The marking shall be done in such a manner as not to permanently indent, deform or otherwise damage the jacket or outer covering. The marking shall be visible and legible from the outside of the cable assembly, except for armored cables. The marking shall be legible after the aging stability and stress crack resistance tests. The following details shall apply.

a. Manufacturer's name, registered trademark or identification.

b. Date Code. On parts which are reworked, the manufacturer shall mark a new date code prefixed by the letter "R" without removal of the prior markings.

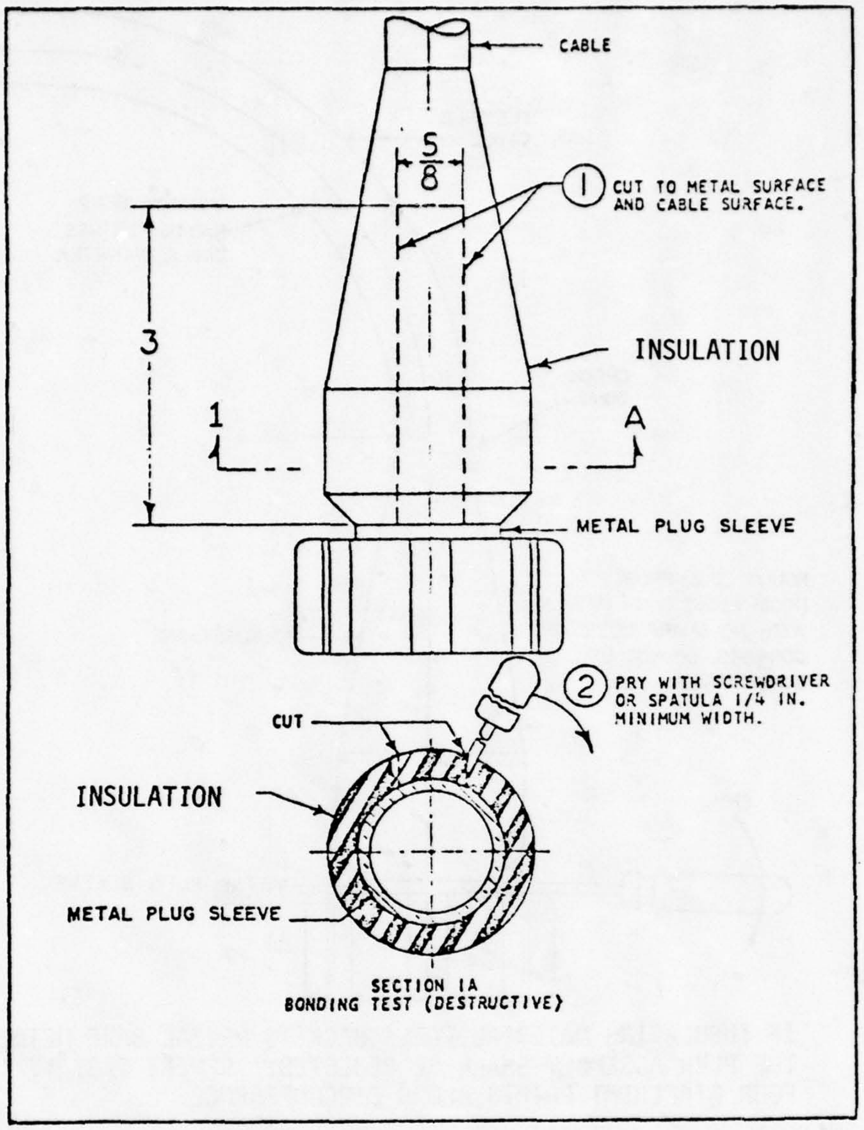
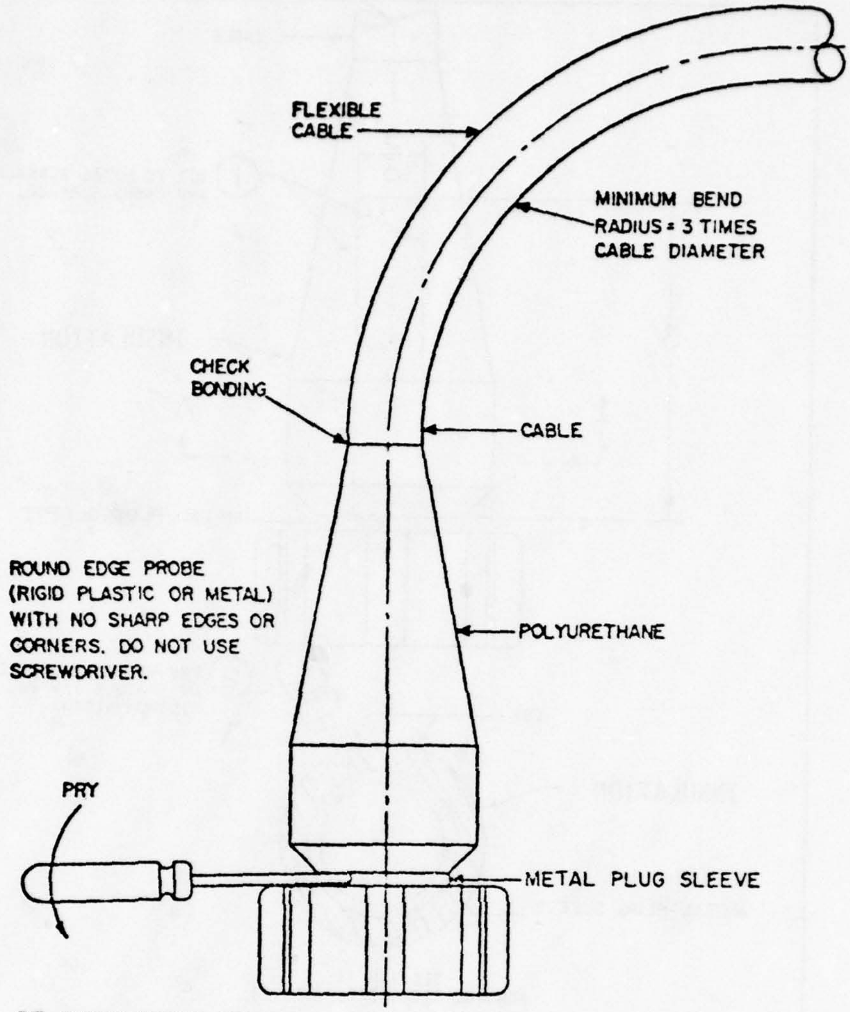


Figure B-2 BONDING TEST



IF INSULATING MATERIAL PEELS BACK TO REVEAL BARE METAL, THE PLUG ASSEMBLY SHALL BE REJECTED. REPEAT TEST AT FOUR DIFFERENT POINTS ALONG CIRCUMFERENCE.

Figure B-3 BONDING TEST (NONDESTRUCTIVE)

3.12 Workmanship. Loose contacts, poor molding fabrication, loose materials, defective bonding, damaged or improperly assembled contacts, peeling, or chipping of plating or finish, galling of mating parts, nicks and burrs of metal parts and post molding warpage will be considered adequate basis for rejection of items of quality inferior for the purpose intended.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.1 Component and material inspection. The supplier is responsible for insuring that components and materials used are manufactured, examined, and tested in accordance with referenced specifications and standards.

4.1.2 Sampling. The unit of product for inspection purposes shall be two cable assemblies.

4.1.3 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-C-45662.

4.2 Classification of inspection. Inspection shall be classified as follows:

a. Qualification inspection (see 4.3).
b. Quality conformance inspection (see 4.4).
c. Inspection of preparation for delivery (see 4.5).

4.2.1 Inspection conditions. Unless otherwise specified herein, all test inspection conditions shall be performed in accordance with the test conditions specified in the "General Requirements" of MIL-STD-202, as follows:

a. Temperature: $25^{o}C \pm 10^{o}C$.

b. Relative humidity: 60 percent ± 15 percent.

c. Atmospheric pressure: 850 to 1100 Newtons/square meter.

4.3 Qualification inspection.

4.3.1 Examination. Each preproduction cable assembly shall be examined in accordance with table B-1. Presence of one or more defects in either preproduction cable assembly shall be cause for rejection of both cable assemblies.

TABLE B-1 Examination

Comm. Caps	Cable assy.	Adapter	Dummy conn.	Defect	Requirement paragraph
X	X	X	-	Pin or socket contacts not as specified.	3.1
X	X	X	X	Dimensions not as specified.	3.3
-	X	-	-	180-degree bend at joint causing visible separation of connector and cable.	3.4
X	X	X	X	Materials or components not as specified.	3.4
-	X	-	-	Bond between cable and connectors cracked.	3.4
-	X	X	X	Attaching means for dummy connectors not as specified.	3.4.5
X	X	X	-	Connectors not electrically or physically serviceable after mating.	3.7
X	X	-	-	Caps have shorting bar missing	3.4.6
X	X	X	X	Identification markings missing or incomplete.	3.11
X	X	X	X	Workmanship not as specified.	3.12

4.3.2 Tests. Following successful completion of the examination, the preproduction cable assemblies shall be tested as indicated in table B-2. Tests shall be conducted in the order listed. Any test result not meeting the applicable requirement paragraph shall constitute failure of the test and shall be cause for rejection of the preproduction cable assemblies.

4.3.3 Qualification samples. Preproduction cable assemblies for which qualification is desired shall be tested in the sequence specified in Table B-2 Specific details on preparation of samples shall be as follows: Each test article subjected to qualification testing shall be provided with a counterpart connector for those tests requiring mating assemblies. The counterpart connectors provided for this purpose shall be unused, previously qualified connectors or new connectors submitted for qualification testing. Manufacturers not producing mating connectors shall submit data substantiating that tests were performed with approved counterpart connectors.

Table B-2 Qualification Inspection

Inspection	Requirement paragraph	Test paragraph
Hardness Disengagement	3.7 - 3.4.2	4.6.2 4.6.3
Continuity	3.8.1	4.6.4.1
Insulation Resistance	3.8.2	4.6.4.2
Dielectric withstanding Voltage	3.8.3	4.6.4.3
Corona	3.8.4	4.6.4.4
Impulse	3.8.5	4.6.4.5
Ozone	3.8.6	4.6.4.6
Electromagnetic Compatibility	3.8.7	4.6.4.7
Operating Voltage	3.8.8	4.6.4.8
Operating Current	3.8.9	4.6.4.8
Fault Current	3.8.10	4.6.4.8.1
Random Vibration	3.10.1	4.6.5.1
Temperature and humidity	3.10.2	4.6.5.2
Moisture Resistance	3.10.3	4.6.5.2
Insulation Resistance	3.8.2	4.6.4.2
Salt Atmosphere	3.10.4	4.6.5.3
Dielectric withstanding Voltage	3.8.3	4.6.4.3
Altitude	3.10.5	4.6.5.4
Corona	3.8.4	4.6.4.4
Bonding	3.10.6	4.6.5.5

4.4 Quality conformance inspection

4.4.1 Inspection of product for delivery. Inspection of product for delivery shall consist of an inspection lot.

4.4.2 Inspection lot. An inspection lot shall consist of all production cable assemblies covered by this specification, produced under essentially the same conditions and offered for inspection at one time. In-process controls, unrelated to lot sizes of finished articles, may be used, provided an equivalent or tighter inspection level is maintained.

4.4.2.1 Rejected lots. If an inspection lot is rejected, the supplier may rework it to correct the defects, or screen out the defective units and resubmit for inspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be kept separate and shall be clearly identified as reinspected lots.

4.4.2.2 Inspection. Inspection shall consist of the applicable tests specified in Table B3 and shall be made on the units which have been subjected to and have passed inspection examination of parameters listed in Table B3.

Table B3. Qualification Conformance Inspection

Inspection	Requirement Paragraph	Test Paragraph
Dielectric withstanding voltage	3.8.3	4.6.5.4
Corona	3.8.4	4.6.6
Insulation Resistance	3.8.2	4.6.14.2

4.4.2.2.1 Disposition of sample units. Sample units which have passed the inspection may be delivered on the contract or purchase order.

4.4.2.2.2 Noncompliance. If a sample fails to pass qualification conformance inspection, the manufacturer shall take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured with essentially

4.4.2.2.2 (Continued)

the same materials, processes, etc. and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the procuring agency, has been taken. After the corrective action has been taken, qualification conformance inspection shall be repeated on additional new samples of the final design. Qualification inspections may be reinstituted; however, final acceptance shall be withheld until the qualification conformance reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action shall be furnished to the cognizant inspection activity and the qualifying activity.

4.5 Inspection of preparation for delivery.

4.5.1 Quality conformance inspection.

4.5.1.1 Unit of product. For the purpose of inspection, a completed cable assembly prepared for shipment shall be considered a unit of product.

4.5.1.2 Sampling. Sampling for examination shall be in accordance with MIL-STD-105.

4.5.1.3 Examination. Samples selected in accordance with 4.5.1.2 shall be examined for the following defects.

101. Materials and containers not as specified for level A or B. Each incorrect material or container shall constitute one defect.
102. Assemblies plugged together, as required.
103. Ends not secured together with cotton tape.
104. Coils coiled beyond minimum safe diameter.
105. Packaging not as specified.
106. Packing not as specified.
107. Strapping not zinc coated for level A.
108. Marking illegible, incorrect, incomplete or missing.
109. Cable assembly ends capped, as required.

4.6 Methods of examination and tests.

4.6.1 Visual and mechanical examination. The cable assembly connectors and accessories shall be visually and mechanically examined to ensure conformance with this specification and the applicable military standards (see 3.1, 3.3, 3.4, 3.11 and 3.12). In-process controls of component parts, unrelated to lot sizes of finished cable assemblies, may be utilized in lieu of examination of these components in the finished cable assemblies to assure conformance of these component parts.

4.6.2 Disengagement. The cable assembly connectors shall be fully mated to securely mounted receptacles. A gradually increasing axial tension shall be applied to the plugs, and the force at separation measured (see 3.7).

4.6.3 Hardness of insert or body material. Determine the hardness of the body material in accordance with FED. TEST METHOD STD. No. 601, method 3021 (see 3.4.2).

4.6.4 Electrical tests. The electrical tests shall be run on each cable assembly by the manufacturer to demonstrate compliance with the requirements of paragraph 3.8 of this specification unless otherwise specified. All electrical tests shall be run with the cable assembly mated with the receptacle.

4.6.4.1 Continuity (see 3.8.1). To establish continuity, 25 volts dc maximum shall be applied to both ends of each conductor and shield of the cable through an appropriate indicator, such as an ohmmeter, light, or buzzer. The test voltage may be applied to the conductors and shields individually or in series.

[illegible] Insulation resistance (see 3.8.2). The insulation resistance [illegible]ined for conductor insulation and for cable jackets, when [illegible] specification sheet.

4.6.4.2.1 Procedure. The test shall be performed on each length of completed cable assembly. The leakage current shall be measured after 1-minute electrification with a direct current potential of not less than 200 nor more than 500 volts. Cable assemblies with individually shielded conductors shall be tested between conductor and shield. Cable jacket insulation resistance measurements shall be made between the overall cable shield and a water bath. The conductor or shield whose insulation is under test shall be connected to the negative terminal of the test equipment and readings shall be taken after 1-minute electrification.

4.6.4.2.2 Observation. The insulation resistance values at 15.5^{o}C. shall be not less than required by the specification sheet. If the measurement is made at a temperature other than 15.5^{o}C., the manufacturer shall correct the measured value to 15.5^{o}C. If the insulation resistance is equal to or greater than that required, when the measurement is made at a temperature greater than 15.5^{o}C., no correction factor need be employed. The manufacturer shall demonstrate that the correction factor used is accurate for his insulating compound.

4.6.4.3 Dielectric Withstanding Voltage (DWV) (see 3.8.3). DWV tests shall be made on all completed cable assemblies.

4.6.4.3.1 Apparatus. The voltage withstand tests shall be made with alternating potential from a source of ample capacity, but in no case less than 5 kilovolt-amperes, having a frequency not greater than 500 Hz and a wave shape approximately a sine wave under all test conditions. The testing voltage may be measured by means of a voltmeter (rms) connected to voltmeter coil in the high-tension winding of the testing transformer, or to a separate instrument transformer.

4.6.4.3.2 Procedure. The test voltages and application (conductor to shield and shield to ground) shall be as required by the specification sheet. The time of application for all voltage withstand tests shall be 1 minute. The initially applied voltage shall be not greater than 1000 volts. The rate of increase shall be approximately uniform and not over 100 percent

4.6.4.3.2 (Continued)
in 10 seconds nor less than 100 percent in 60 seconds. All unarmored cables requiring electrical tests for the jacket shall be immersed in a grounded water bath for at least 1 hour, and tested while still immersed, using the water as the ground.

4.6.4.3.3 Observation. All cable shall withstand without failure the voltages specified on the specification sheet.

4.6.4.3.4 Test voltage. The AC test voltage shall be 160 percent nominal operating voltage for alternating current cables and 56.5% nominal operating voltage for dc cables for one minute. Where dc peak = $\frac{1}{2\sqrt{2}}$ Ac peak-to-peak.

4.6.4.4 Corona (see 3.8.4). Two specimens shall be tested in accordance with ASTMD1868, (Circuit, Figure 1). The detector used shall have a sensitivity of less than 1.0 picocoulomb before it is loaded with the test specimen. The detector shall have a uniform frequency response up to 500 kiloherz. The following details shall apply:

a. Magnitude of test voltage - 110% rated voltage.
b. Nature of potential-dc. AC test may be used, properly rated.
c. Duration of application of test voltage - partial discharges shall be measured for 60 minutes after operating voltage is attained. Voltage shall be increased from 0 to operating test voltage at a rate of 500 volts per second.
d. Points of application of test voltage - center conductor to shield.
e. Examination after test: cable assemblies shall be visably examined for evidence of breakdown, arcing, or other visable damage.
f. Partial discharges shall not exceed more than one discharge per minute above 10 pc. Partial discharges greater than 50 pc are unacceptable. Partial discharges within the cable assembly shall be calculated per ASTMD1868 or ASTMD3382-75.

4.6.4.5 Impulse voltage test (see 3.8.5). The cable assembly shall be tested with a basic insulation level surge voltage (BIL) according to the AIEE-EEI-NEMA Standard Basic Insulation Levels, NEMA Publication No. 109, dated January 1941. The BIL shall be in accordance with the following definition:

> "Basic impulse insulation levels are reference levels expressed as impulse crest voltage with a standard wave not longer than 1-1/2 x 40 microseconds (1-1/2 microseonds rise and 40 microseconds decay, Figure B4). Apparatus insulation as demonstrated by suitable tests shall have capability equal to, or greater than, the basic insulation level."

The BIL levels to which the cable assembly shall be tested are 350 percent rated voltage.

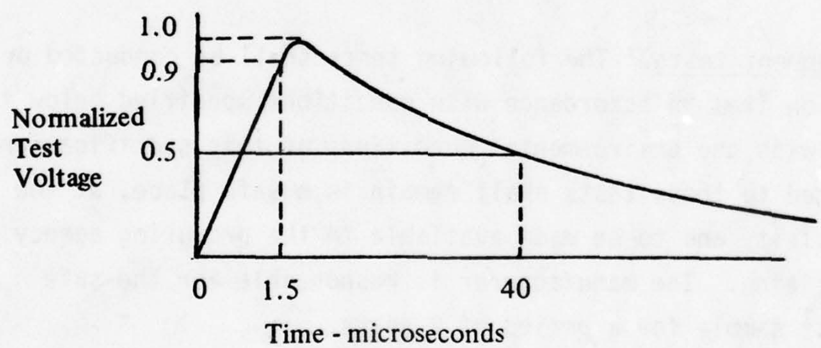


FIGURE B4 Basic insulation level test voltage profile

4.6.4.6 Ozone. Unless certification is provided, the cable assembly shall be tested in accordance with ASTM D470 using an ozone concentration of 100 to 150 parts per million (see 3.1 and 3.8.6).

4.6.4.7 Electromagnetic compatibility (see 3.8.7). The cable assembly shall meet the requirements of RE02 and RE04 tests of MIL-STD-461A. When the cable assembly is subjected to the pulse voltage (rated voltage only) of 4.6.4.5 or an equivalent sine wave. The sine wave shall include 100 Hz, 400 Hz, 1000 Hz, 10KHz, 100KHz, 1MHz, 10MHz and 20 MHz.

4.6.4.8 Operating. Connect the cable assembly to a power source and dummy load, and check for operation at rated voltage and current. Connect and disconnect the connectors five times. Short circuits, open circuits, arcing during operation, or failure of the connector to connect or disconnect shall constitute failure of this test.

4.6.4.8.1 Fault current. Connect the cable assembly to a low-voltage, high-current power source and dummy load, and check for fault current operation (see 3.8.10).

4.6.5 Environment tests. The following tests shall be conducted on the first production item in accordance with conditions specified below to assure compliance with the environmental conditions of this specification. The sample subjected to these tests shall remain in a safe place, at the manufacturer's facility and to be made available to the procuring agency upon request in writing. The manufacturer is responsible for the safe keeping of the test sample for a period of 2 years.

4.6.5.1 Vibration. Install a mating plug on each end of the cable assembly that is provided with a plug. Equip each plug with at least 3 feet of cable with the ends bared. The cable assembly and accessories shall be mounted as follows and subjected to the applicable vibration test. Each cable assembly shall be mounted on a suitable fixture, which, in turn, shall be attached to a vibration table. A suitable sensor shall monitor the vibration of the cable assembly at a point on or near the receptacle.

4.6.5.1 (Continued)

The accessory units shall be engaged with the cable assembly and tightened to the detailed torque requirements; normal locking means without the use of safety wire. The cable assembly shall be clamped to nonvibrating points at least 8 inches from the rear of the connectors. The clamping length shall be chosen to avoid resonance of the wire cables.

4.6.5.1.1 Procedure. The mated connector shall be mounted as specified in 4.6.5.1 and vibrated in accordance with method 2005, test condition II of MIL-STD-1344. The contact shall be wired in series with 100 $\pm$100 milliamperes allowed to flow. A suitable instrument shall be employed to monitor the current flow and to indicate discontinuity of contact or interruption of current flow (see 3.10.1).

4.6.5.2 Temperature and humidity (see 3.10.2 and 3.10.3). Maintain chambers used for temperature and humidity tests within plus or minus 2°C of the specified temperature throughout the test.

4.6.5.2.1 Low-temperature storage and operation. Install a mating plug on each end of the cable assembly that is provided with a plug. Equip each mating plug with a minimum of 3 feet of cable with bared ends. Place the cable assemblies in a test chamber and expose to an ambient temperature of minus 55°C for 24 hours. Test each assembly as specified in 4.6.4.2. Any defects in connectors, adapters, dummies, or plugs such as cracks or separation of connectors from the cable shall constitute failure of this test.

4.6.5.2.2 High-temperature and humidity storage and operation. Install a mating plug on each end of each cable assembly provided with a plug. Equip the mating plug with a minimum of 3 feet of cable. Place the cable assemblies in the test chamber and expose to an ambient temperature of plus 125°F. and maximum humidity for a period of 24 hours. Test each assembly as specified in 4.6.4.2. Any defects in connectors, adapters, dummies, or plugs such as cracks or separation of connectors from the cable shall constitute failure of this test.

4.6.5.3 Salt atmosphere (see 3.10.4). The cable assemblies shall be exposed to a salt-fog atmosphere for a period of 48 hours in accordance with MIL-STD-810, method 409, procedure 1. (See 3.10.4.) The test shall be conducted at $25^{\circ} \pm 5^{\circ}C$.

4.6.5.4 Altitude (see 3.10.5). Install a mating plug on each end of the cable assembly that is provided with a plug. Equip each mating plug with a minimum of 3 feet of cable with bared ends. Place the cable assemblies in the test chamber and expose to altitude at room ambient temperature. Mated connectors shall be tested in accordance with MIL-STD-810. The following details shall apply:

a. The connector cable ends shall be located outside the chamber. The cable ends may be submerged in an insulating liquid or sealed.
b. Paragraphs 4.4 and 5(e) of method 1004 shall not apply.
c. Test altitude shall be 50,000 feet unless otherwise specified.
d. After 15 minutes at altitude, the cable assembly shall be tested for corona as specified in 4.6.4.4

4.6.5.5 Bonding (see 3.10.6). One plug of the cable assembly with 3 feet excess cable in a fully cured condition as determined by correct durometer shall be tested as follows:

a. Install a dummy mating plug on a solid bulkhead.
b. Install the test plug in the mating dummy plug and tighten per specification.
c. Bend the cable per the minimum bend radius for the cable assembly two times in four directions at room ambient.

Any defects in the connector, cable, or test plug such as a crack between the connector metal and jacket shall constitute a failure of this test.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packing and packaging. Preservation, packing, and packaging shall be in accordance with MIL-B-121. Cable assemblies shall be packaged as complete assemblies as indicated on the applicable specification sheet and shall be individually wrapped in a protective sheet and separated one from the other. The supplier may use his own commercial practice provided it affords protection against deterioration and damage from the supplier to the initial destination.

5.1.1 Connector protection. Each connector on a cable assembly shall be terminated into a shorted mating cap during shipping and storage.

5.2 Packing. The subject commodity shall be packed in substantial commercial containers of the type, size, and kind commonly used for the purpose, so constructed as to insure acceptance and safe delivery by common or other carriers, at the lowest rate, to point of delivery called for in the contract or purchase order.

5.3 Marking.

5.3.1 Exterior container. Exterior container shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. The cable assemblies are intended for use in airborne, high-voltage, high-power electrical power systems.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of this criteria document.
b. Applicable specification sheet (see 3.1).
c. Level of preservation and packaging and level of packing required (see 5.1 and 5.2).

6.3 Preproduction model. Any changes or deviations of production cable assemblies from the approved preproduction models during production will be subject to the approval of the contracting officer. Approval of the preproduction models will not relieve the supplier of his obligation to furnish cable assemblies conforming to this specification.

APPENDIX C

CAPACITORS

CAPACITORS, HIGH VOLTAGE, FIXED, PLASTIC (OR PAPER-PLASTIC) DIELECTRIC,
(HERMETICALLY SEALED IN METAL, CERAMIC, OR GLASS CASES),
ESTABLISHED AND NON-ESTABLISHED RELIABILITY,
GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for established reliability (ER) and non-established reliability (non-ER), direct current (dc), plastic or paper-plastic dielectric, high-voltage fixed capacitors, hermetically sealed in metal or ceramic or glass cases. Capacitors meeting the established reliability requirements specified herein have failure rate (FR) levels ranging from 2.0 percent to 0.001 percent per 1,000 hours (see 1.2.1.9). These FR levels are established at a 90-percent confidence level and maintained at a 10-percent producer's risk and are based on life tests performed at maximum rated voltage and maximum rated temperature. An acceleration factor of 5:1 has been used to relate the life test data obtained at 140 percent of rated dc voltage at the applicable high test temperature to the rated voltage at the applicable high test temperature. This specification also covers removable mounting retainers for use with applicable capacitors (see 3.1).

1.2 Classification.

1.2.1 Part number. The part number shall be in the following form, and as specified (see 3.1 and 6.2):

CQR09	A	1	M	C	152	K	1	M
ER style 1.2.1.1	Terminal 1.2.1.2	Circuit 1.2.1.3	Characteristic 1.2.1.4	Voltage 1.2.1.5	Capacitance 1.2.1.6	Capacitance tolerance 1.2.1.7	Vibration grade 1.2.1.8	Failure rate level 1.2.1.9

CQ09	A	1	M	C	152	K	1
Non-ER style 1.2.1.1	Terminal 1.2.1.2	Circuit 1.2.1.3	Characteristic 1.2.1.4	Voltage 1.2.1.5	Capacitance 1.2.1.6	Capacitance tolerance 1.2.1.7	Vibration grade 1.2.1.8

1.2.1.1 Style. The style is identified by either the five-letter symbol "CQHVR" or the four-letter symbol "CQHV" followed by a two-digit number. The letters identify plastic (or paper-plastic) dielectric, high voltage, fixed capacitor, hermetically sealed in metal, ceramic or glass cases. The symbol "CQHVR" identifies established reliability (ER) capacitors; the symbol "CHQV" identifies capacitors for which no specific reliability requirements are specified (non-ER). The first digit following the letter symbols identifies the general shape of the case, and the second digit identifies specific details other than case size. Each style designation may include a family of case sizes.

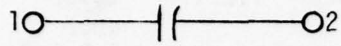
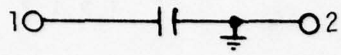
1.2.1.2 Terminal. The terminal is identified by a single letter in accordance with table C1.

TABLE C1. Terminal.

Symbol	Type of terminal
C-------	Threaded stud and nuts.
D&H-----	Pillar insulator for use at altitudes up to 7,500 feet (22.8 inches of mercury). Furnished with threaded stud and nuts.
E-------	Pillar insulator for use at altitudes up to 50,000 feet (3.4 inches of mercury).
J-------	Busing insulator with corona protected terminal.
K-------	High voltage connector per MIL-C-5015 (modified).

1.2.1.3 Circuit. The circuit diagram and the number of terminals are identified by a single digit in accordance with table C2.

TABLE C2. Circuit diagram and number of terminals.

Symbol	Circuit diagram	Number of terminals
1		2
3		3

1.2.1.4 Characteristic. The characteristic is identified by a single letter in accordance with table C3.

TABLE C3. Characteristic.

	Values for characteristics							
	E&K	P	T	M	N	Q&S	R&U	L
High ambient test temperature, degrees centigrade $\pm 3^{\circ}$C. 1/ ------------------	85	65	170	85	125	125	85	65
Low ambient test temperature, degrees centigrade $^{+0^{\circ}}_{-5^{\circ}}$C. --------------------	-65	-65	-65	-65	-55	-55	-55	-30
Life-test dc voltage, in percent of the dc voltage rating (see 4.7.22):								
Watt-second group (see 6.5.3):								
I (0.5 watt-second and less)----	140	140	140	140	140	140	140	---
II (0.5+ to 5 watt-seconds) -----	140	---	140	---	---	---	---	---
III (5+ to 50 watt-seconds) ------	140	---	140	---	---	---	---	100
IV (greater than 50 watt-seconds)	140	---	140	---	---	---	---	100
Flashpoint of impregnant or filling compound, degrees centigrade --------	142	142	217	142	142	142	135	176

1/ For characteristic K, voltage derating may be necessary at the high ambient test temperature (see 3.1).

1.2.1.5 Voltage. The dc voltage rating for continuous operation at the high ambient test temperature specified in table C3 (except for characteristic K which is for 85°C operation), is identified by a single letter in accordance with table C4.

TABLE C4. DC voltage rating.

Symbol	DC voltage rating KV Crest
A -----	12.5
B -----	15
C -----	25
E -----	50
F -----	75
G -----	100
H -----	125
J -----	150
K -----	175
L -----	200
M -----	250
N -----	300

1.2.1.6 Capacitance. The nominal capacitance value expressed in picofarads (pF) is identified by a three-digit number; the first two digits represent significant figures, and the last digit specifies the number of zeros to follow.

1.2.1.7 Capacitance tolerance. The capacitance tolerance in percent is identified by a single letter in accordance with table C5.

TABLE C5. Capacitance tolerance.

Symbol	Capacitance tolerance Percent (±)
F ------	1
G ------	2
J ------	5
K ------	10

1.2.1.8 Vibration grade. The vibration grade is identified by a single digit in accordance with table C6.

TABLE C6. Vibration grade.

Symbol	Frequency range Hz	Acceleration G
1 ------	10 to 55 inclusive	----
3 ------	10 to 2,000 inclusive	15

1.2.1.9 Failure rate level. The failure level in percent per 1,000 hours is identified by a single letter in accordance with table C7, and is based on rated voltage at the high test temperature, as applicable.

TABLE C7. Failure rate level.

Symbol	Failure rate level (percent per 1,000 hours)
L ------	2.0
M ------	1.0
P ------	0.1
R ------	0.01
S ------	0.001

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-I-10 - Insulating Compound, Electrical, Ceramic, Class L.

MIL-C-39028 - Capacitors, Packaging of.

(See Supplement 1 for list of associated specification sheets.)

STANDARDS

MILITARY

MIL-STD-105	-	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-202	-	Test Methods for Electronic and Electrical Component Parts.
MIL-STD-690	-	Failure Rate Sampling Plans and Procedures.
MIL-STD-790	-	Reliability Assurance program for Electronic Parts Specifications.
MIL-STD-810	-	Environmental Test Methods.
MIL-STD-1285	-	Marking of Electrical and Electronic Parts.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

ASTM D1868	-	Detection and Measurement of Discharge (Corona) Pulses in Evaluation of Insulation Systems.
ASTM D3382-75	-	Measurement of Energy and Integrated Charge Transfer Due to Partial Discharges (Corona) Using Bridge Techniques.
NEMA Publication No. 109	-	AIEE-EEI-NEMA Standard Basic Insulation Level.

NATIONAL BUREAU OF STANDARDS

Handbook H28 - Screw-Thread Standards for Federal Services.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D92-57 - Method of Test for Flash and Fire Points by Cleveland Open Cup.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA. 19103)

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern (see 6.2).

3.2 Qualification. Capacitors and retainers furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.4 and 6.4). In addition, the manufacturer shall obtain certification from the qualifying activity that the reliability assurance requirements of 4.1.1 have been met and are being maintained for the ER styles. Unless procured from the manufacturers or his authorized distributor listed or approved for listing on the qualified products list, ER parts furnished under this specification shall not be considered as having met the requirements of this specification.

3.3 Reliability (applicable to ER capacitors only, see 3.1). Reliability of ER capacitors furnished under this specification shall be established and maintained in accordance with the procedures and requirements specified in MIL-STD-790 and MIL-STD-690 with details specified in 4.1.1, 4.4.4, 4.5, and 4.6.1.3.

3.4 Material. The material shall be as specified herein; however, when a definite material is not specified, a material shall be used which will enable the capacitors and retainers to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.4.1 Impregnant and filling compounds. Compounds used in the impregnation and filling of capacitors shall be chemically inactive with respect to the capacitor element and the case (see 3.5.1). The compound, either in the state of original application or as a result of having aged, shall have no adverse effect on the performance of the capacitor. For liquid-filled

AD-A069 473 BOEING AEROSPACE CO SEATTLE WASH F/G 9/5

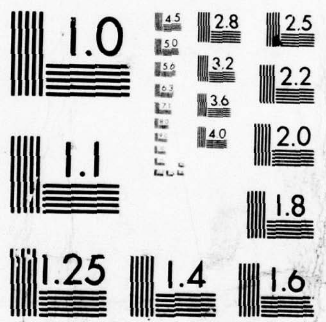
HIGH VOLTAGE SPECIFICATIONS AND TESTS (AIRBORNE EQUIPMENT). (U)

APR 79 W G DUNBAR, W P KOENIG F33615-77-C-2054

UNCLASSIFIED AFAPL-TR-79-2024 NL

3 OF 6

AD A069473



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

capacitors, the same material shall be used for impregnating as is used for filling (see 6.3).

3.4.2 Dielectric material. Dielectric material (see 3.1) utilized in the fabrication of capacitors shall be one of the following materials:

Characteristic	Material
P ------------	Polystyrene
M ------------	Polyethylene terephthalate
E & K ---------	Paper and polyethylene terephthalate
T ------------	Polytetrafluoroethylene
Q ------------	Polycarbonate
S ------------	Polysulfone
L ------------	Polypropylene
N ------------	Polymide
R ------------	Polyvinyl fluoride
U ------------	Polyvinyliuene fluoride

3.5 Design and construction. Capacitors and retainers shall be of the design, construction, and physical dimensions specified (see 3.1).

3.5.1 Case. Each capacitor shall be enclosed in a hermetically-sealed metal or ceramic or glass case (see 3.1) which will prevent leakage of the impregnant or filling compound and, in addition, will protect the capacitor element from moisture and mechanical damage under all test conditions specified herein. Ceramic used for case materials shall conform to MIL-I-10. The use of exterior cardboard sleeves for insulating purposes shall not be permitted.

3.5.2 Noninductive construction. Unless otherwise specified (see 3.1), tubular capacitors shall be of extended-foil construction. When tab construction is used, each pair of tabs shall be brought from opposite foils within one turn of the foil winding from each other, unless otherwise specified (see 3.1).

3.5.3 Terminals.

3.5.3.1 Case as terminal. When the case is used as a terminal, any protective coating applied to the mounting surfaces shall be such as to provide a direct conducting path for an electric current from the case to the surface on which it is mounted.

3.5.3.2 Corona suppressors. Corona suppressors shall be supplied when screw terminals of paragraph 3.5.3.3 are used at rated voltages greater than 15kVDC. The terminal and nut shall not exceed the height of the corona suppressor.

3.5.3.3 Screw terminals. Screw terminals shall be supplied with one nut, one flat washer, and one lockwasher.

3.5.3.4 Wire leads and pins. Leads and pins shall be of copper or copper covered steel. Copper covered steel leads and pins shall have a minimum of 30 percent of the conductivity of electrolytic copper. Leads and pins shall be coated with solder having a tin content of 40 to 70 percent.

3.5.3.5 Terminal insulators. Terminal insulators shall be glass or ceramic.

3.5.3.6 Connectors. Connectors shall be hermetically sealed, circular threaded, high voltage with solder or brazed contacts.

3.5.4 Threaded parts. All threaded parts shall be as specified (see 3.1), and in accordance with H28.

3.5.4.1 Engagement of threaded parts. All threaded parts shall engage by at least three full threads.

3.5.4.2 Locking of screw-thread assemblies. All screw-thread assemblies shall be rendered resistant to loosening under vibration. Lockwashers shall be provided under all nuts.

3.5.5 Safety.

3.5.5.1 Containment. Internal failure at rated voltage of one of ten parallel equal rating capacitors shall not cause solids, liquids or gases to escape the capacitor envelope.

3.5.5.2 Shorting. Disconnected capacitors shall not accrue terminal voltage faster than 15 volts per hour. Except for intervals of two hours maximum, terminals of individual and assemblies of capacitors shall be shorted with a metallic conductor during storage, shipping and handling.

3.6 Burn-in (ERs only, when applicable, see 3.1). When capacitors are tested as specified in 4.7.3, there shall be no evidence of damage, arcing or breakdown.

3.7 Radiographic inspection (ERs only, when applicable, see 3.1). When capacitors are tested as specified in 4.7.4, X-ray examination shall disclose no evidence of improperly made connections, misalignments of seals or eyelets, substandard soldering or structural weakness, or solder particles or slivers attached to one end.

3.8 Thermal shock. When tested as specified in 4.7.5, capacitors and retainers shall withstand the extremes of high and low temperatures without visible damage.

3.9 Seal. When capacitors are tested as specified in 4.7.6, there shall be no continuous visible stream of bubbles or other evidence of leakage.

3.10 Dielectric withstanding voltage (DWV).

3.10.1 Capacitors. When capacitors are tested as specified in 4.7.7.1, there shall be no momentary or intermittent arcing or other indication of breakdown, nor shall there be any visible evidence of damage.

3.10.2 <u>Sleeving (when applicable, see 3.1)</u>. When capacitors are tested as specified in 4.7.7.2, the insulating sleeve shall withstand the specified potential without breakdown.

3.11 <u>Barometric pressure (reduced) (when applicable, see 3.1)</u>. When capacitors are tested as specified in 4.7.8, there shall be no momentary or intermittent arcing or other indication of breakdown, nor shall there be any visible evidence of damage.

3.12 <u>Insulation resistance</u>.

3.12.1 <u>Sleeving (when applicable, see 3.1)</u>. When measured as specified in 4.7.9, the insulation resistance shall be not less than 1,000 megohms.

3.12.2 <u>Terminal to terminal</u>. When measured as specified in 4.7.9, the insulation resistance shall be not less than the applicable values specified (see 3.1).

3.12.3 <u>Terminal to case</u>. When measured as specified in 4.7.9, the insulation resistance between any terminal and case, when the case is not a terminal, shall exceed 50,000 megohms, unless otherwise specified (see 3.1).

3.13 <u>Capacitance</u>. When measured as specified in 4.7.10, the capacitance shall be within the tolerance specified (see 3.1).

3.14 <u>Dissipation factor</u>. When measured as specified in 4.7.11, the dissipation factor shall not exceed the applicable value specified (see 3.1).

3.15 <u>Vibration</u>. When capacitors are tested as specified in 4.7.12, there shall be no intermittent contacts or momentary arcing, or other indication of breakdown, nor shall there be any open-or-short circuiting or evidence of mechanical damage. In addition, retainers, as tested to 4.7.12 shall exhibit no evidence of mechanical damage.

3.16 Salt spray (corrosion) (metal surfaces only, see 3.1). When capacitors or retainers are tested as specified in 4.7.13, there shall be no evidence of harmful corrosion, and at least 90 percent of any exposed metal surfaces of the capacitor or retainer shall be protected by the finish. For capacitors or retainers with painted surfaces, not more than 10 percent of the surfaces shall be affected by flaking, peeling, or blistering of paint. There shall be no evidence of unwrapping of or mechanical damage to insulating sleeves. In addition, corrosion of the terminal hardware or mounting surface shall not exceed 10 percent of the surface area. Marking shall remain legible.

NOTE: Harmful corrosion shall be construed as any type of corrosion which in any way interferes with the mechanical or electrical performance of the capacitor or retainer, as applicable.

3.17 Immersion. When tested as specified in 4.7.14, capacitors or retainers, as applicable, shall meet the following requirements:

(a) Capacitors:

Dielectric withstanding voltage:

Insulating sleeves (when applicable, see 3.1)	Not less than rated voltage.
Terminal to terminal	As specified in 3.10.1.
Terminal to case	As specified in 3.10.1.

Insulation resistance at 25°C:

Insulating sleeves (when applicable, see 3.1)	Not less than 1,000 megohms.
Terminal to terminal	Unless otherwise specified, not less than 60 percent of the value specified in 3.12.2.
Terminal to case	Unless otherwise specified, not less than 50 percent of the value specified in 3.12.3.

Capacitance ----------------------------	Shall change not more than ± 1.0 percent from the value obtained when measured as specified in 4.7.10.
Dissipation factor ----------------------	Shall not exceed 120 percent of the initial value specified (see 3.1).

(b) Capacitors and retainers:

Visual examination --------------------	There shall be no harmful or extensive corrosion of the capacitors or retainers. The marking shall remain legible.

3.18 Solderability (wire leads only, see 3.1). When capacitors are tested as specified in 4.7.15, the dipped portion of the terminals shall conform to the solid-wire termination criteria of method 208 of MIL-STD-202.

3.19 Shock (specified pulse). When capacitors are tested as specified in 4.7.16, there shall be no intermittent contacts of 0.5 ms or greater duration, or arcing or other indications of breakdown, nor shall there be any open or short circuiting or evidence of mechanical damage.

3.20 Terminal strength. When capacitors are tested as specified in 4.7.17, there shall be no mechanical damage to the capacitor or terminals.

3.21 Moisture resistance. When tested as specified in 4.7.18, capacitors or retainers, as applicable, shall meet the following requirements:

(a) Capacitors:

Dielectric withstanding voltage:

Insulating sleeves (when applicable, see 3.1) ----------------------------	Not less than 4,000 Vdc.
Terminal to terminal ------------------	As specified in 3.10.1.
Terminals to case (circuit diagram 1 only) ----------------------------	As specified in 3.10.1.

Insulation resistance at 25°C:	
Insulating sleeves (when applicable, see 3.1)	Not less than 1,000 megohms.
Terminal to terminal	Not less than 60 percent of the value specified in 3.12.2.
Terminal to case (circuit diagram 1 only)	Not less than 50 percent of the value specified in 3.12.3.
Capacitance	Shall change not more than $\pm$0.5 percent ($\pm$2.0 percent from characteristic M) from the value obtained when measured as specified in 4.7.10.
Dissipation factor	Shall not exceed 120 percent of the initial values specified (see 3.1).
(b) Capacitors and retainers	
Visual examination	There shall be no harmful or extensive corrosion of the capacitors or retainers. The marking shall remain legible.

3.22 Dielectric absorption (when specified, see 3.1). When measured as specified in 4.7.19, the dielectric absorption shall not exceed the value specified (see 3.1).

3.23 Stability at low and high temperatures. When capacitors are tested as specified in 4.7.20, there shall be no indication of breakdown or arcing, nor shall there be any open-or short-circuiting or any visible evidence of mechanical damage. The capacitance changes at the specified temperatures shall not exceed the applicable limits specified (see 3.1) from value at 25°C.

3.24 Temperature coefficient (characteristic P only, see 3.1). When measured as specified in 4.7.21, the temperature coefficient shall not exceed -120 ± 50 parts per million per degree Celsius (ppm/^{o}C).

3.25 Life. When tested as specified in 4.7.22, capacitors shall meet the following requirements:

Insulation resistance at 25^{o}C --------------	Unless otherwise specified, not less than 60 percent of the value specified in 3.12.1.
Capacitance -------------------------------	Shall change not more than the percent specified (see 3.1) of the initial value obtained when measured as specified in 4.7.10.
Dissipation factor ------------------------	Unless otherwise specified, shall not exceed the initial value specified (see 3.1).
Visual examination ------------------------	There shall be no leakage of impregnant or filling compound or deformation of the case either during or after the test.

3.26 Fungus. The manufacturer shall certify that all external materials are fungus resistant or shall perform the test specified in 4.7.23. When capacitors are tested as specified in 4.7.23, examination shall disclose no evidence of fungus growth on the external surface.

3.27 Resistance to solvents. When capacitors are tested as specified in 4.7.24, there shall be no evidence of mechanical damage and the marking shall remain legible.

3.28 Resistance to soldering heat (applicable to wire-lead capacitors only). When tested as specified in 4.7.25, capacitors shall meet the following requirements:

Insulation resistance at 25°C	As specified in 3.12.
Capacitance	Change not more than 5 percent from the initial value obtained when measured as specified in 4.7.10.
Dissipation factor	Shall not exceed initial limit.

3.29 Flashpoint of impregnant or filling compound. When measured as specified in 4.7.26, the flashpoint of impregnant or filling compound shall be equal to or greater than 142°C unless otherwise specified (see 3.1).

3.30 Marking.

3.30.1 Capacitors. Marking of capacitors shall conform to method I of MIL-STD-1285 and shall include the part number, "JAN" brand, trademark, source code, date code, lot symbol, capacitance (in µF), capacitance tolerance, and rated voltage, and when applicable, failure rate level. Unless otherwise specified (see 3.1), capacitors shall be marked as shown in the following example:

EXAMPLE:

CQR09A1MC152K1M	- Part number.
JAN TM 12345	- "JAN" brand (ER styles only), trademark and source code.
7120A. 0022µF	- Date code, lot symbol and capacitance.
10% 1000 VDC	- Capacitance tolerance and rated voltage.

3.30.2 Partial marking. For tubular capacitors with case sizes of .175 x .406, .195 x .406 and .235 x .406, the following partial marking may be used.

```
                TM J 09 A 1
   Trademark ───┘  │  │  │ └── Circuit diagram
   (optional)      │  │  └──── Terminal
   J for JAN, ─────┘  └─────── Style number
  (when applicable)

                MC 152 G M
Characteristic ─┘   │  │ └── Failure rate level (when applicable)
   Voltage ─────────┘  └──── Capacitance tolerance
                          Capacitance value (see 1.2.1.6)

                12345 212
  Source code ────┘   └── Date code
```

3.30.3 Retainers. Retainers shall be marked with the part number, trademark, and source code. Marking shall be on the outer surface of the retainers.

3.30.4 JAN and J marking (ER styles only). The United States Government has adopted, and is exercising legitimate control over, the certification marks "JAN" and "J", respectively, to indicate electrical equipment, namely, resistors, capacitors, electron tubes and the like, procured by, or manufactured for use by, or for the Government in accordance with standard Government specifications. Accordingly, capacitors procured to, and meeting all of, the criteria specified herein and in applicable specification sheets shall bear the certification mark "JAN", except that capacitors too small to bear the certification mark "JAN" shall bear the letter "J". Capacitors furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein and in applicable specification sheets shall not bear "JAN" or "J". In the event a capacitor sample fails to meet the requirements of this specification and applicable specification sheets, the manufacturer shall

remove the "JAN" or the "J" from the sample tested and also from all capacitors represented by the sample. The United States Government has obtained Certificate of Registration No. 504, 860 for the certification mark "JAN".

3.30.5 Remarking when supplying to higher FR levels. A manufacturer supplying to higher FR levels as provided by MIL-STD-690 shall not re-mark the parts unless specified in the contract or purchase order (see 6.2).

3.30.6 Non-ER marking. An ER part may be marked and furnished as a non-ER part, if produced on the same assembly line, and provided it is subjected to and meets all the inspection requirements of the ER part.

3.31 Workmanship. Capacitors and retainers shall be processed in such a manner as to be uniform in quality and shall be free from pits, corrosion, cracks, rough edges, and other defects that will affect life, serviceability, or appearance.

3.31.1 Soldering.

3.31.1.1 Flux. Flux for soldering of electrical connections shall be rosin, rosin and alcohol, or rosin and turpentine. No acid or acid salts shall be used in preparation for or during soldering; however, exception is permitted for preliminary tinning of electrical connections and for tinning or soldering of mechanical joints not used to complete electrical circuits, but in no case shall acid salts be used where they can come in contact with insulating material. Where acid or acid salts are used as permitted herein, they shall be completely neutralized and removed immediately after use. All excess flux and solder shall be removed. Where possible, electrical connections shall be mechanically secure before soldering and electrically continuous after soldering.

3.31.1.2 Process. There shall be no sharp points or rough surfaces resulting from insufficient heating. The minimum necessary amount of flux and solder shall be used for electrical connections. Any means employed to remove an unavoidable excess of flux shall not incur the risk of loose particles of flux,

brush bristles, or other foreign material remaining in or on the capacitor; flux being spread over a large area; or damage to the capacitor. Insulation material that has been subjected to heating during the soldering operation shall be undamaged and parts fastened thereto shall not have become loosened.

3.31.2 Riveting (retainers only). The riveting operation shall be performed carefully to insure that the rivet is tight and satisfactorily headed.

3.32 Partial discharges. When measured as specified in paragraph 4.7.28 the partial discharges shall not exceed the value specified (see 3.1). This test is for capacitors with operation voltages higher than 10 kV.

3.33 Impulse voltage. When measured as specified in paragraph 4.7.29 there shall be no momentary or intermittent arcing or other indication of breakdown or flashover, nor shall there be any visible evidence of damage. This test is for capacitors with operating voltage exceeding 10 kV.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government . The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.1 Reliability assurance program (applicable to ER parts only). A reliability assurance program shall be established and maintained in accordance with MIL-STD-790, with the following exceptions:

(a) Only the following of paragraph 5.2.7 (j) shall apply: 'the manufacturer shall as a minimum be able to identify the time period during which the final production operation was performed on each item of product prior to final test. The date or lot code marked on each part shall be identified to a production lot.'

(b) Paragraph 5.2.11.3 shall not apply.

4.2 Classification of inspection. The inspections specified herein are classified as follows:

(a) Qualification inspection (see 4.4).
(b) Retention of qualification (see 4.5).
(c) Quality conformance inspection (see 4.6).

4.3 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

4.4 Qualification inspection 1/. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.4) on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. The number of capacitors or retainers to be submitted for qualification inspection shall be as specified in table C8 or C9, respectively, or paragraph 10 of this specification.

4.4.2 Inspection routine.

4.4.2.1 Capacitor submission. Capacitors shall be subjected to the qualification inspection specified in table C8 in the order shown. All sample units shall be divided as specified in table C8 for groups I through VIII inclusive, and subjected to the inspection for their particular group; for combined voltage group submissions, each type shall be equally represented in each group.

4.4.2.2 Retainer submission. Fourteen sample retainers shall be subjected to the examination and tests specified in table C9 in the order shown in

1/ Qualification approval will be based on the successful completion of the test specified in table VIII, and will not be withheld pending completion of the extended-life test of 4.4.4(a).

TABLE C8. Qualification inspection for capacitors.

Examination or test	Requirement paragraph	Method paragraph	NON-ER		ER	
			Number of sample units to be inspected	Number of defectives allowed 1/	Number of sample units to be inspected	Number of defectives allowed 1/
Group I						
Visual and mechanical examination (internal):	---	4.7.2	2	0	2	0
Material, design, construction, and workmanship - - - - -	3.1, 3.4, 3.5, and 3.31					
Group II						
Visual and mechanical examination (external):	---	4.7.2	6	1	10	0
Physical dimensions, marking, and workmanship 2/ - - -	3.1, 3.5, and 3.30 to 3.31.2 incl.					
Containment	3.5.5.1	4.7.27				
Burn-in (ER only, when applicable) 3/ - - -	3.6	4.7.3				

1/ A sample unit having one or more defects will be considered as a single defective.

2/ Marking defects are based on visual examination only and will be charged only for illegible, incomplete, or incorrect marking.

3/ Nondestructive tests.

TABLE C8. Qualification inspection for capacitors. (cont'd)

Examination or test	Requirement paragraph	Method paragraph	NON-ER		ER	
			Number of sample units to be inspected	Number of defectives allowed 1/	Number of sample units to be inspected	Number of defectives allowed 1/
Radiographic inspection (ER only, when applicable) 3/ - - -	3.7	4.7.4				
Temperature cycling 3/	3.8	4.7.5				
Seal - - - - - - - - - -	3.9	4.7.6				
Dielectric withstanding voltage 3/ - - - - - -	3.10	4.7.7				
Barometric pressure (reduced) (when applicable) 3/ - - -	3.11	4.7.8	6	1	10	0
Insulation resistance 3/ - - - - - - - -	3.12	4.7.9				
Capacitance 3/ - - - -	3.13	4.7.10				
Dissipation factor 3/	3.14	4.7.11				
Partial discharges - -	3.32	4.7.28				
Impulse Voltage - - - -	3.33	4.7.29				
Group III						
Vibration - - - - - - -	3.15	4.7.12	6	1	12	1

1/ A sample unit having one or more defects will be considered as a single defective.

3/ Nondestructive tests.

TABLE C8. Qualification inspection for capacitors. (cont'd)

Examination or test	Requirement paragraph	Method paragraph	NON-ER: Number of sample units to be Inspected	NON-ER: Number of defectives allowed 1/	ER: Number of sample units to be inspected	ER: Number of defectives allowed 1/
Salt spray (corrosion) (metal case only) - -	3.16	4.7.13	6	1	12	1
Immersion - - - - - - - -	3.17	4.7.14				
Group IV						
Solderability (wire leads only) - - - - - -	3.18	4.7.15	6	1	6	1 1
Group V						
Shock (specified pulse) - - - - - - - -	3.19	4.7.16		1		
Terminal strength - - -	3.20	4.7.17	6	1	12	1
Moisture resistance - -	3.21	4.7.18				
Group VI						
Dielectric absorption (when specified) - - -	3.22	4.7.19				
Stability at low and high temperatures 3/	3.23	4.7.20	24	1	40	1

1/ A sample unit having one or more defects will be considered as a single defective.

3/ Nondestructive tests.

TABLE C8. Qualification inspection for capacitors. (cont'd)

Examination or test	Requirement paragraph	Method paragraph	NON-ER		ER	
			Number of sample units to be inspected	Number of defectives allowed 1/	Number of sample units to be inspected	Number of defectives allowed 1/
Temperature coefficient (characteristic P) - -	3.24	4.7.21	24	1	40	1
Life - - - - - - - - - -	3.25	4.7.22				
Group VII						
Fungus - - - - - - - - -	3.26	4.7.23	N/A	---	5	1
Resistance to solvents - - - - - -	3.27	4.7.24			10	
Resistance to soldering heat (wire lead only) - - - - -	3.28	4.7.25			5	
Group VIII						
Flashpoint of impregnant or filling compound - - - - - -	3.29	4.7.26	24/	---	24/	---

1/ A sample unit having one or more defects will be considered as a single defective.

4/ Two samples shall be taken from the .25-pound impregnant or filling compound submitted.

paragraph 20.2. Two specimens of each type represented in a sample shall be subjected to group I tests. Retainers shall then be subjected to the tests of group II. During these tests, one set of each retainer type shall support a capacitor of the same case designation with which it is normally used (see 3.1). Tests on retainers may be run concurrently with those specified for capacitors in 4.4.2.1. Each retainer shall be considered as a specimen for the purpose of determining defectives.

4.4.3 Failures. Failures in excess of those allowed in table C8 or C9, as applicable, shall be cause for refusal to grant qualification approval.

4.4.4 Failure rate (FR) qualification (applicable to ER parts only). FR qualification for capacitors shall be in accordance with the general and detailed requirements of MIL-STD-690 and the following details:

(a) Procedure I - Qualification at the initial FR level. Level "M" (1.0 percent), of FRSP-90 shall apply. Sample units shall be subjected to the qualification inspection specified in group V, table VIII (see 4.4.2.1). The entire life test sample shall be continued on test to 6,000 hours as specified in 4.7.22.3, upon completion of the 2,000 hour qualification.

(b) Procedure II - Extension of qualification to lower FR levels. To extend qualification to the "R" (0.01 percent), and "S" (0.001 percent) FR levels, data from two or more styles of similar construction may be combined.

(c) Procedure III - Maintenance of FR level qualification. Maintenance period B of FRSP-10 shall apply. Regardless of the number of production lots produced during this period, the specified number of unit hours shall be accumulated to maintain qualification (see 4.6.1).

4.5 Retention of qualification. To retain qualification, the supplier shall forward a report at 6-month intervals to the qualifying activity. The qualifying activity shall establish the initial reporting date. The report shall consist of:

(a) A summary of the results of the tests performed for inspection of product for delivery (groups A and B), indicating as a minimum the number of lots that have passed and the number that have failed. The results of tests of all reworked lots shall be identified and accounted for.

(b) A summary of the results of tests performed for periodic inspection (group C), including the number and mode of failures. The summary shall include results of all periodic inspection tests performed and completed during the 6-month period. If the summary of the test results indicates nonconformance with specification requirements, and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list.

TABLE C9. Qualification inspection for retainers.

Examination or test	Requirement paragraph	Method paragraph	Number of specimens to be inspected	Number defectives allowed 1/
Group I				
Visual and mechanical examination	3.1, 3.5 to 3.5.4.2 as applicable and 3.30 to 3.31.2 incl.	4.7.2	2	0
Group II				
Vibration 2/	3.15	4.7.12		
Salt spray (corrosion)	3.16	4.7.13	12	1
Temperature cycling	3.8	4.7.5		

1/ A specimen having one or more defects shall be considered as a single defective.

2/ During vibration tests, one set of each retainer type shall support a capacitor or a dummy of comparable weight and size.

Failure to submit the report within 30 days after the end of each 6 month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the supplier shall immediately notify the qualifying activity at any time during the 6 month period that the inspection data indicates failure of the qualified product to meet the requirements of the specification.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item. If during 3 consecutive reporting periods there has been no production, the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative product of each style to testing in accordance with the qualification inspection requirements.

4.6 Quality conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspections.

4.6.1.1 Inspection lot. An inspection lot shall consist of all capacitors in one or more styles, produced under essentially the same conditions, and offered for inspection at one time. The sample selected from the lot shall be representative of the styles in the lot. ER parts shall be kept separate from non-ER parts. Styles may be grouped by characteristic as follows:

Group	Characteristic	Style
1--	--------------	All non-ER styles may be grouped by characteristic.

4.6.1.2 Group A inspection. Group A inspection shall consist of the examination and tests specified in table C10, **and shall be made on the same set of sample units in the order shown.**

4.6.1.2.1 Sampling plan. Subgroup 1 tests, except as indicated in table **C10 and** subgroup 2 tests, shall be performed on each ER capacitor offered for acceptance. Such tests shall not be repeated for purposes of reinspection. Statistical

sampling and inspection for subgroups 1, 2, and 3 for non-ER capacitors, and subgroup 3 for ER capacitors shall be in accordance with MIL-STD-105 for general inspection level II. The acceptable quality level (AQL) and limiting quality (LQ) shall be as specified in table C10. At the option of the manufacturer, numerically lower AQL levels may be used as long as the specified LQ is not exceeded numerically.

4.6.1.2.2 Manufacturer's production inspection (for ER parts only). If the manufacturer performs tests equal to or more stringent than those specified in subgroup 1, table C10, as the final step of his production process, group A, subgroup 1 inspection may be waived and the data resulting from the manufacturer's production tests may be used instead. Authority to waive the subgroup 1 inspection shall be granted by the qualifying activity only. The following criteria shall be complied with:

(a) Tests conducted by the manufacturer during production shall be clearly identical to or more stringent than that specified for subgroup 1. Test conditions shall be equal to or more stringent than those specified for subgroup 1.

(b) Manufacturer subjects 100 percent of the product supplied under this specification to his production tests.

(c) The parameters measured and the failure criteria shall be the same as, or more stringent than, those specified herein.

(d) The lot rejection criteria is the same as, or more stringent than, those specified herein.

(e) The manufacturer shall make available all information concerning the test procedures and instrumentation used in his production tests. This data shall be provided as part of the evaluation required for MIL-STD-790. The manufacturer shall also make available to the Government all records of all detail test data resulting from production tests.

(f) Once approved, the manufacturer shall not change the test procedure or criteria without prior notification and concurrence by the qualifying activity.

TABLE C10. Group A inspection.

Examination or test	Requirement paragraph	Method paragraph	NON-ER AQL (% defective) Major	NON-ER AQL (% defective) Minor	ER Quality level (% defective)
SUBGROUP 1					
Containment	3.5.5.1	4.7.27			
Burn-in 1/ - - -	3.6	4.7.3	Not applicable		100% inspection
Radiographic inspection 1/ ---	3.7	4.7.4	Not applicable		100% inspection
Temperature cycling-	3.8	4.7.5	.65	---	100% inspection
Seal -------------	3.9	4.7.6	.65	---	100% inspection
Dielectric withstanding voltage (capacitor only)-	3.10.1	4.7.7.1	.65	---	100% inspection
Partial discharges-	3.32	4.7.28	.65	---	100% inspection
Impulse voltage ---	3.33	4.7.29	.65	---	100% inspection
SUBGROUP 2					
Insulation resistance (at 25°C)---	3.12	4.7.9	.65	---	100% inspection
Capacitance ------	3.13	4.7.10	.65	---	100% inspection
Dissipation factor-----------	3.14	4.7.11	.65	---	100% inspection
SUBGROUP 3					
Visual and mechanical examination (external):					
Physical dimensions----------	3.1,3.5	4.7.2	.65	2.5	1.0(AQL) 7.6(LQ)
Marking --------	3.30	4.7.2	.65	2.5	1.0(AQL) 7.6(LQ)
Workmanship ----	3.31	4.7.2	.65	2.5	1.0(AQL) 7.6(LQ)

4.6.1.2.3 Rejected lots. Lots rejected by the group A inspection shall be segregated from new lots and those lots that have passed inspection. Lots rejected because of failures in subgroup 2 may be offered for acceptance only if the manufacturer inspects all units in the lot for those quality characteristics found defective in the sample, and after removing all defective units found, reinspects the lot using the tightened inspection procedure of MIL-STD-105. Resubmitted lots shall be kept separate from new lots, and shall be clearly identified as resubmitted lots. If, during the 100-percent inspection of subgroups 1 and 2 (ER parts only), screening requires that over 5 percent of the capacitors be discarded, the lot shall be rejected.

4.6.1.2.4 Disposition of sample units. Sample units which have passed all the group A inspection may be delivered on the contract or order, if the lot is accepted.

4.6.1.3 Group B inspection.

4.6.1.3.1 For ERs and non-ERs. Group B inspection shall consist of the tests specified in subgroups 1 and 2 of table C11, in the order shown, and shall be performed on sample units which have been subjected to and have passed the applicable tests of group A inspection.

4.6.1.3.1.1 Sampling plan. The sampling plan for subgroups 1 and 2, as applicable, shall be in accordance with MIL-STD-105 for special inspection level S-4. (The sample size selected for these tests shall be based on the lot size.) The AQL and LQ shall be as specified in table C11. At the option of the manufacturer, a numerically lower AQL may be used as long as the LQ is not exceeded numerically.

4.6.1.3.2 For FR level L. Group B inspection shall consist of the tests specified in table C11 and shall be performed on sample units which have been subjected to and have passed group A inspection. The lot conformance FR procedures are as specified in procedure IV of MIL-STD-690 with the following details and exceptions:

(a) Lot sampling - 6 sample units (minimum).

(b) Duration of lot conformance FR test - 240 hours.

(c) Failure criteria - See 3.25, one failure allowed.

(d) Permissible combinations - See 4.6.1.1.

(e) Disposition of samples and inspection lot - Samples may be delivered on contract or order provided they are 100-percent inspected to verify that they meet all requirements listed in table C11, subgroup 2. However, a minimum of 3 sample units shall be randomly selected from the sample units and subjected to the extended life test as specified in 4.6.1.3.4. The inspection lot may be shipped upon successful completion of lot conformance FR test.

4.6.1.3.3 Extended life test. Sample units which have been selected for extended life test (see 4.6.1.3.2) shall be subjected to an additional 5,760 hours of life test as specified in 4.7.22.3.2.

4.6.1.3.4 Reject lots. If an inspection lot is rejected as a result of failure to pass group B inspection, the lot shall not be resubmitted. However, if the lot is rejected because of failure to pass the stability at low and high temperature test of subgroup 1, the lot may be resubmitted provided the defective units are removed and the lot is then subjected to 100-percent inspection for those characteristics found defective. Resubmitted lots shall be kept separate from new lots, and shall be clearly identified as resubmitted lots. Even though the lot has been rejected, those units which were predesignated for extended life testing shall remain or be placed on test for the full length of time.

4.6.2 Periodic inspection. Periodic inspection shall consist of group C inspection. Except where the results of these inspections show noncompliance with the applicable requirement (see 4.6.2.1.4), delivery of products which have passed groups A and B inspections shall not be delayed pending results of periodic inspection.

TABLE C11. Group B inspection.

Test	Requirement paragraph	Method paragraph	Quality levels (percent defective) Sample selection	
			NON-ER	ER
Subgroup 1				
Insulation resistance (at high ambient test temperature) -------	3.12	4.7.9	2.5 (AQL)	2.5 (AQL) 13 (LQ)
Dielectric absorption (when specified) ----------------	3.22	4.7.19		
Stability at low and high temperatures --------------------	3.23	4.7.20		
Temperature coefficient (characteristic P only) ---------	3.24	4.7.21		
Barometric pressure (reduced) -----	3.11	4.7.8		
				Number of sample units to be inspected
				FR level
Subgroup 2				
Life (240-hour)-------------------	3.25	4.7.22.2.1	2.5(AQL)	6

4.6.2.1 Group C inspection. Group C inspection shall be performed on sample units which have been subjected to and have passed the applicable tests (by FR level, failure rate, and non-ER styles) for group A inspection and shall consist of the tests specified in table C12 in the order shown. Test data shall be reviewed as part of the complete verification of qualification.

4.6.2.1.1 Sampling plan.

4.6.2.1.1.1 For all non-ER styles and FR levels. Sample units shall be selected from the first lot and from production lots every two months for subgroups 1, 2, 3 and 4, and every 12 months for subgroup 5. The highest watt-second rating in each style, characteristic, and voltage manufactured during the specified periods shall be represented in at least the approximate ratio of production. A different sample shall be selected for each subgroup.

4.6.2.1.1.2 For FR levels. In addition to the tests specified in 4.6.2.1.1.1, a minimum of 10 sample units from each inspection 1.4 (see 4.6.1.1) shall be subjected to subgroup 4 of table C12 (see 4.6.1.3.3). Allowable failures shall be as specified in table C4, maintenance period A of MIL-STD-690.

4.6.2.1.2 Failures. If the number of failures exceeds the number allowed in table C12, the sample shall be considered to have failed.

4.6.2.1.3 Disposition of sample units. Sample units which have been subjected to group C inspection shall not be delivered on the contract or order.

4.6.2.1.4 Noncompliance (applicable to both ER and non-ER parts). If a sample fails to pass group C inspection, the manufacturer shall take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed,

TABLE C12. Group C inspection.

TEST	Requirement paragraph	Method paragraph	Number of sample units to be inspected	Number of defectives allowed	
				NON-ER	ER
Subgroup 1					
Shock (specified pulse) (not applicable to ceramic-or-glass-cased units)	3.19	4.7.16	12	1 (Subgroup 1); 1 (Subgroups 1, 2 and 3 combined)	1 (Subgroup 1); 1 (Subgroups 1, 2 and 3 combined)
Vibration	3.15	4.7.12			
Salt spray (corrosion) (metal cases only)	3.16	4.7.13			
Immersion	3.17	4.7.14			
Subgroup 2					
Solderability (wire lead styles only)	3.18	4.7.15	6	1 (Subgroups 2 and 3)	1 (Subgroups 2 and 3)
Subgroup 3					
Terminal strength	3.20	4.7.17	12		
Moisture resistance	3.21	4.7.18			
Dielectric withstanding voltage (sleeving only)	3.10.2	4.7.7.2			
Subgroup 4					
Life	3.25	4.7.22.2.2	12 (non-ER) ER (see 4.6.2.1.1)	1	See 4.6.2.1.1
Subgroup 5 (every 6 months)					
Resistance to solvents	3.27	4.7.24	6	N/A	1
Resistance to soldering heat (wire-lead styles only)	3.28	4.7.25			

at the option of the Government). Groups A and B inspections may be reinstituted; however, final acceptance shall be withheld until the group C reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the qualifying activity and the contracting officer or purchaser.

4.6.3 Inspection of preparation for delevery. Sample packages and packs shall be selected and inspected in accordance with MIL-C-39028, to verify conformance with the requirements of section 5 of this specification.

4.7 Methods of examination and test.

4.7.1 Measurement conditions.

4.7.1.1 AC measurements. Alternating-current (ac) measurements shall be made at the frequency specified. The magnitude of the ac voltage shall be limited to 1.0 volt root mean square (rms). The maximum dc bias voltage shall be 2.2 volts for all ac measurements of capacitors.

4.7.1.2 Reference measurements. When requirements are based on comparative measurements made before and after conditioning, the reference measurement shall be considered the last measurement made at $25^{\circ} \pm 5^{\circ}C$ prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

4.7.1.3 Power supply. The power supply used for life testing shall have a regulation of ± 2 percent or less of the rated voltage. The power source employed for dc leakage current measurements shall be stabilized to at least ± 100 parts per million. No voltage fluctuations shall occur during measurements that would produce a variation in the current measurement as read with any acceptable dc leakage current tester used to test capacitors.

4.7.2 Visual and mechanical examination. Capacitors and retainers shall be examined to verify that the material, design, construction, physical

dimensions, marking, and workmanship are in accordance with the applicable requirements. (See 3.1, 3.4 to 3.5.3 inclusive, and 3.30 to 3.31.1.2 inclusive.)

4.7.3 Burn-in (see 3.6) (ERs only, when applicable, see 3.1). Capacitors shall be subjected to 140 percent of the dc rated voltage at the high ambient test temperature for 48 $^{+8}_{-0}$ hours. During this test, capacitors shall be adequately protected against temporary voltage surges of 10 percent or more of the test voltage. After the test, capacitors shall show no evidence of damage, arcing, or breakdown.

4.7.4 Radiographic inspection (X-ray) (see 3.7) (ERs only, when applicable, see 3.1). Capacitors shall be tested in accordance with method 209 of MIL-STD-202. The following details shall apply:

(a) Radiographic quality - Sufficient definition to determine that specimens are free from defects specified in 3.7.
(b) Image-quality indicator - A sample part of the same type as the part being radiographed that contains either an actual or simulated defect which is at least 10 percent smaller than the smallest defect to be detected.
(c) Positions of specimen - Two views perpendicular to the terminal axis. After first view, specimen shall be rotated 90 degrees for the second view.
(d) Evaluation of images:
    (1) Special kind of viewing equipment - Magnifying glass.
    (2) Magnification - 10X.
    (3) Defects to be sought in specimen - As specified in 3.7.

4.7.5 Temperature cycling (see 3.8). Capacitors and retainers shall be tested in accordance with method 107 of MIL-STD-202. The following details and exceptions shall apply:

(a) Test condition letter - Unless otherwise specified, A, except that during step 3, capacitors shall be conditioned at the high ambient test temperature (see 3.1).

(b) Measurements before and after cycling - Not applicable.

4.7.6 Seal (see 3.9). Capacitors shall be tested in accordance with method 112, MIL-STD-202. The following details shall apply:

(a) Test condition letter - As specified, see 3.1.
(b) Examination after test - Capacitors shall be visually examined for evidence of leakage.

4.7.6.1 Seal (alternative test (see 3.9)). For capacitors with a liquid impregnant, the following seal test may be substituted: Capacitors shall be placed on a clean sheet of absorbent paper and exposed to the applicable high ambient test temperature for a minimum of 1 hour. The capacitors shall then be visually examined for evidence of leakage of impregnant or filling compounds or bubbles from the seal. Capacitors to be subjected to the salt spray (corrosion), and immersion tests may be excluded from the seal test until after the salt spray (corrosion), and immersion tests are completed.

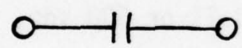
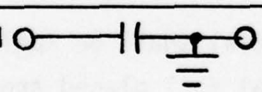
4.7.7 Dielectric withstanding voltage (see 3.10).

4.7.7.1 Capacitors. Capacitors shall be tested in accordance with method 301, MIL-STD-202. The following details and exceptions shall apply:

(a) Magnitude of test voltage - As specified in table C13.
(b) Nature of potential - dc.
(c) Duration of application of test voltage - As specified in table C13.
(d) Points of application of test voltage - As specified in table C13.
(e) Examinations after test - Capacitors shall be visually examined for evidence of breakdown, arcing, or other visible damage.

4.7.7.2 Sleeving (see 3.10.2) (when applicable, see 3.1). With the capacitor horizontally mounted, a single loop of No. 20 AWG wire shall be secured around the insulating sleeve of the capacitor so that it extends downward from the capacitor 3 inches minimum, and the two ends of the wire twisted in about three cross turns. A 1-pound minimum weight shall then be suspended from the looped wire. After exposure in this position for a minimum of 24 hours, at the maximum rated temperature ±3°C, a dc voltage of 4,000 volts minimum, shall be applied between the case and the looped wire. The rate of voltage application shall be 500 volts per second and the duration of application of test voltage shall be 15 seconds, minimum.

TABLE C13. Dielectric-withstanding-voltage test details.

Circuit-diagram symbol	Circuit diagram	Test points	Test connections	Magnitude of test voltage	Duration of application of voltage
				Percent rated dc voltage	Minutes
1	1  2	Terminal to terminal	1 to 2	200 1/	1 2/
		Terminal to case 3/	1 and 2 to case	200	1
3	1  2	Terminal to terminal	1 to 2 or 1 to case	200 1/	1 2/

1/ 175 percent rated dc voltage after immersion, and moisture resistance tests.

2/ For the 100-percent inspection specified in 4.6.1.2, the capacitors shall be subjected, at the option of the manufacturer, to the application of 200 percent of rated dc voltage for not less than 5 seconds, or 160 percent for not less than 15 seconds.

3/ For quality conformance inspection, application of potential may be made between each terminal individually and the case.

4.7.8 Barometric pressure (reduced) (see 3.11) (when applicable, see 3.1). Capacitors shall be tested in accordance with method 105 of MIL-STD-202. The following details and exceptions shall apply:

(a) Method of mounting - By normal mounting means.
(b) Test condition - Unless otherwise specified (see 3.1), capacitors shall be subjected to a pressure of 0.82 inch of mercury (80,000 feet).
(c) Test during subjection to reduced pressure - Unless otherwise specified (see 3.1), the capacitors shall not be subjected to a dc potential at altitudes above 6,000 feet.

4.7.9 Insulation resistance (see 3.12). Capacitors shall be tested in accordance with method 302, MIL-STD-202. The following details and exceptions shall apply:

(a) Test potential:
  (1) Insulating sleeves - When applicable (see 3.1) - Test condition B.
  (2) Terminal to terminal and terminal to case - A potential equal to the rated dc voltage (see 3.1) or 500 Vdc, whichever is less.
(b) Special conditions - The time constant of the measurement circuit with the capacitor connected shall not exceed 30 seconds.
(c) Points of measurement:
  (1) Insulating sleeves - The test potential shall be applied between the case and a piece of metal foil placed around the insulating sleeve; the metal foil shall be of such dimension as to allow at least .125-inch surface exposure of the insulating sleeve on each end (see 3.12.1).
  (2) Terminal to terminal - Insulation resistance shall be measured between terminals at the maximum rated temperature, $\pm 3^{\circ}C$, and at $25^{\circ} \pm 3^{\circ}C$ (see 3.12.2).
  (3) Terminals to case - When the case is not a terminal, the measurement shall be made between each terminal and the case at $25^{\circ} \pm 3^{\circ}C$ (see 3.12.3).
(d) Electrification time - 15 seconds.

4.7.10 Capacitance (see 3.13). Capacitors shall be tested in accordance with method 305 of MIL-STD-202. The following details shall apply:

(a) Test frequency - 1,000 ±100 Hertz (Hz) for capacitors whose nominal capacitance does not exceed 1 μF and whose dc voltage rating does not exceed 3,000 volts. For capacitors not within these limits, measurements shall be made at frequency of 100 ±6 Hz or corrected thereto.

(b) Limit of accuracy - Shall be within ±0.1 percent.

4.7.11 Dissipation factor (see 3.14). The dissipation factor shall be measured with an ac voltage not greater than 20 percent of the dc voltage rating, at a frequency of 1,000 ±100 Hz, for capacitors whose nominal capacitance does not exceed 1 μF and whose dc voltage rating does not exceed 3,000 volts. For capacitors not within these limits, measurements shall be made at a frequency of 100 ± 10 Hz or corrected thereto. Measurement accuracy shall be one of the following:

(a) For dial reading - ±2 percent of dial reading or .001, whichever is greater.

(b) For digital readout - ±.001 percent ±2 percent of reading.

4.7.12 Vibration (see 3.15 and 3.1).

4.7.12.1 Low frequency. Capacitors shall be tested in accordance with method 201 of MIL-STD-202. The following details and exceptions shall apply:

(a) Tests and measurements prior to vibration - Not applicable.

(b) Method of mounting - Securely fastened by normal mounting means, except that capacitors without mounting retainers in sizes 1.562 inch long or 0.670 inch in diameter or larger shall be mounted by a supplemental means other than the wire leads. Wire-lead capacitors shall be secured .5 ±.125 inch from the case. The extraneous leads beyond the .5 inch securing point may be removed or supplemental support may be added.

(c) Duration of vibration:
For tubular styles - 4 hours (2 hours in each of 2 mutually perpendicular planes).

For rectangular styles - 6 hours (2 hours in each of 3 mutually perpendicular planes).

(d) Tests and measurements during vibration - During the last 30 minutes of vibration in each direction, a signal of 1 ± 0.2 Kilohertz (kHz) at a level of 1 ± 0.5 volts shall be placed across the capacitor and measured with suitable ac detecting equipment to determine open- or short-circuits, or intermittent contacts. The accuracy of the detecting equipment shall be sufficient to detect any interruption with a duration of 0.5 ms or greater.

(e) Examination after vibration - Capacitors shall be visually examined for evidence of mechanical damage.

4.7.12.2 High frequency. Capacitors and retainers shall be tested in accordance with method 204 of MIL-STD-202. The following details and exceptions shall apply.

(a) Mounting of specimens - Capacitors shall be rigidly mounted by the body to a vibration test apparatus. Wire-lead capacitors shall be secured $.5\pm.125$ inch from the case. The extraneous leads beyond the .5 inch securing point may be removed or supplemental support may be added.

(b) .Electrical-load conditions - During the test, a potential of 125 percent of the dc rated voltage shall be applied between the terminals of the capacitor.

(c) Test condition letter - B, with exception as specified (see 3.1).

(d) Measurements - During the last cycle in each direction, a signal of 1 ± 0.2 kHz at a level of 1 ± 0.5 volts shall be placed across the capacitor and measured with a suitable ac recording device (a permanent record is not necessary for this test) to determine open- or short-circuits, or intermittent contacts. The accuracy of the detecting equipment shall be sufficient to detect any interruption with a duration of 0.5 ms or greater.

(e) Measurements and examination after vibration - After the test, with capacitors still mounted on the vibration jig, the insulating sleeve shall be tested for dielectric withstanding voltage, as specified in 4.7.7, with a potential of 2,000 Vdc between the case and bracket. Capacitors and retainers shall be visually examined for evidence of mechanical damage.

4.7.13 Salt spray(corrosion) (see 3.16). Capacitors and retainers shall be tested in accordance with method 101, MIL-STD-202. The following details and exceptions shall apply:

(a) Applicable salt solution - The salt solution concentration shall be 5 percent.
(b) Test condition letter - B (48 hours).
(c) Examination after exposure - Capacitors and retainers shall be visually examined for evidence of harmful corrosion, unwrapping of or mechanical damage to insulating sleeves (when applicable), and obliteration of marking.

4.7.14 Immersion (see 3.17). Within 4 to 24 hours after completion of temperature cycling, capacitors and retainers shall be tested in accordance with method 104 of MIL-STD-202. The following details shall apply:

(a) Test condition letter - B.
(b) Measurements after final cycle - For capacitors with insulating sleeves, dielectric withstanding voltage, and insulation resistance at 25^{O}C shall be measured as specified in 4.7.7 and 4.7.9, respectively. The test potential shall be applied between the case and a piece of metal foil placed around the insulating sleeve; the metal foil shall be of such dimension as to allow at least .125-inch surface exposure of the insulating sleeve on each end. In addition, dielectric withstanding voltage and insulation resistance at 25^{O}C of all capacitors shall be measured as specified in 4.7.7 and 4.7.9, respectively. Capacitors and retainers shall then be examined for harmful or extensive corrosion and obliteration of marking.

4.7.15 Solderability (wire leads only, see 3.1) (see 3.18). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. The following details shall apply:

(a) Number of terminations to be tested - Both leads of the capacitor shall be subjected to the solderability test.

(b) Depth of immersion in flux and solder - The leads shall be immersed to within .125 inch of the capacitor body.

4.7.16 Shock (specified pulse) (see 3.19). Capacitors and retainers shall be tested in accordance with method 213 of MIL-STD-202. The following details shall apply:

(a) Mounting - The body of the capacitor shall be securely fastened by mounting retainers. The leads shall be soldered to rigidly supported terminals so spaced that the length of each lead from the capacitor shall be 1/2 ± 1/8 inch from the edge of the supporting terminal.

(b) Test condition letter - I (100 G).

(c) Electrical loading during shock - During the test, a potential of 125 percent of the dc voltage rating shall be applied between the terminals of the capacitor.

(d) Measurements during shock - During the test, observations shall be made to determine intermittent contact or arcing or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption with a duration of 0.5 ms or greater.

(e) Examinations after test - Capacitors shall be visually examined for evidence of breaking, arcing, fractures, or any other visible mechanical damage. Retainers shall be visually examined for mechanical damage.

4.7.17 Terminal strength (see 3.20). Capacitors shall be tested in accordance with method 211 of MIL-STD-202. The following details and exceptions shall apply:

(a) Test condition letter - As specified (see 3.1).

(b) Examination after test - The capacitors and terminals shall be examined for mechanical damage.

4.7.18 Moisture resistance (see 3.21). Capacitors and retainers shall be tested in accordance with method 102, test condition D, MIL-STD-202, except that no measurement shall be made before and after cycling. Capacitors shall then be tested in accordance with method 106, MIL-STD-202. The following details and exceptions shall apply:

(a) Initial measurements - Not applicable.

(b) Polarization voltage - During steps 1 to 6, inclusive, a dc potential of 100 volts shall be applied across the terminals of 50 percent of the capacitors. No potential shall be applied to the remaining 50 percent of the capacitors.

(c) Loading voltage - Not applicable.

(d) Final measurements - After the final cycle, the capacitors shall be conditioned at $25^{\circ} \pm 5^{\circ}C$ and a relative humidity of 50 ± 5 percent for a period of at least 22 hours but not more than 24 hours. Dielectric withstanding voltage and insulation resistance at $25^{\circ}C$ shall be measured on insulating sleeves as specified in 4.7.7 and 4.7.9, respectively. The test potential shall be applied between the case and a piece of metal foil placed around the insulating sleeve. The metal foil shall be of such dimension as to allow at least .125-inch surface exposure of the insulating sleeve on each end. In addition, dielectric withstanding voltage, insulation resistance, capacitance, and dissipation factor at $25^{\circ}C$, of all capacitors shall be measured as specified in 4.7.7, 4.7.9, 4.7.10, and 4.7.11, respectively.

After the test, capacitors and retainers shall be visually examined for evidence of harmful corrosion and obliteration of marking: capacitors shall be examined for unwrapping of or mechanical damage to insulated sleeves, when applicable.

4.7.19 Dielectric absorption (see 3.22) (when specified, see 3.1). The capacitor shall be charged at the dc voltage rating for 1 hour ± 1 minute. The initial surge current shall not exceed 50 milliamperes. At the end of this period, the capacitor shall be disconnected from the power source and discharged through a 5 ohm $\pm$ 2 percent resistor for 10 ± 1 seconds. The discharge resistor shall be disconnected from the

capacitor (recovery voltage) shall be measured with an electrometer or other suitable device having an input resistance of 10,000 megohms or greater. Recovery voltage shall be read at the maximum voltage within a 15-minute period. The dielectric absorption shall be computed from the following formula:

$$d = \frac{V_1}{V_2} \times 100$$

Where:

d = Percent dielectric absorption.
V_1 = Maximum recovery voltage.
V_2 = Charging voltage.

For an alternate production test method see figure C1.

4.7.20 Stability at low and high temperatures (see 3.23). Capacitors shall be placed in a chamber maintained at $-65^{\circ}\,{}^{+0^{\circ}}_{-5^{\circ}}$C or $-55^{\circ}\,{}^{+0^{\circ}}_{-5^{\circ}}$ C (as applicable, see 3.1), and a potential equal to the dc rated voltage shall be applied at this condition for 48 $\pm$4 hours. The air within the conditioning chamber shall be circulated. Before capacitors are removed from the conditioning chamber, capacitance shall be measured at the applicable low temperature (see 3.1) as specified in 4.7.9. Capacitance shall then be measured at the following temperatures as specified in 4.7.9 (the measurement at each temperature shall be recorded when two successive readings taken at 5-minute intervals indicate no change in capacitance):

1) $25^{\circ} \pm 5^{\circ}$C
2) High ambient test temperature (see Table C3)
3) $25^{\circ} \pm 5^{\circ}$

After the test, capacitors shall be visually examined for evidence of breakdown, arcing, open- and short-circuiting, and other visible mechanical damage.

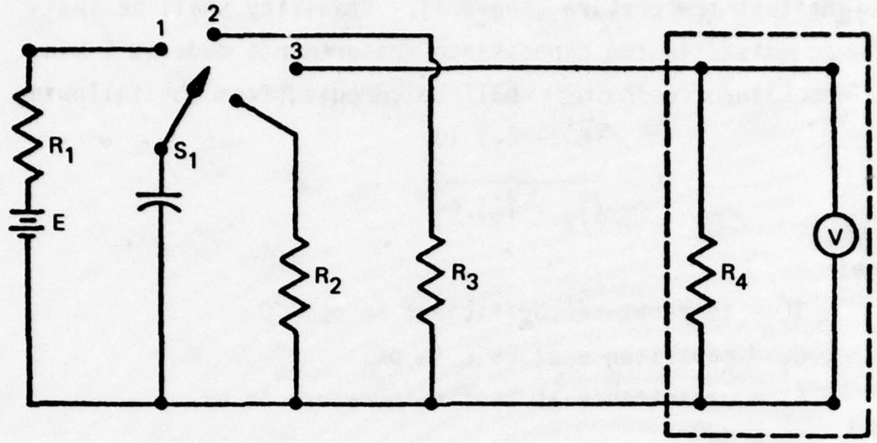


FIGURE C1. Typical production dielectric absorption test method.

E = dc rated dc voltage or 100 volts dc, whichever is less ($\pm 2\%$).

R_1 and R_2 = 1000 Ohms $\pm 20\%$ (This value not critical.)

R_3 = 5 Ohms $\pm 1\%$.

R_4 = 10,000 Megohms - Minimum

Suggest use of $\pm$1230A GR electrometer or equivalent set to 10,000 Megohms range input resistance.

NOTES:

1. Charge for 5 minutes $\pm$ 10 seconds with switch in position 1.
2. Switch in position 2 for 5 seconds $\pm$ 0.5 seconds.
3. Switch in position 3 for 1 minute.
4. After 1 minute read recovery voltage and compute as a percentage of charge voltage.
5. Switch to position 4, discharge and remove.

4.7.21 Temperature coefficient (see 3.24) (characteristic P only, see 3.1). Capacitance measurements shall be made after the capacitors have been stabilized at each of the following temperatures: -65°C, +25°C, and the high ambient test temperature (see 3.1). Stability shall be indicated when no change exists in two capacitance measurements made at 5-minute intervals. Temperature coefficient shall be computed from the following formula:

$$TC = \frac{(C_2 - C_1)\ 10^6}{(T_2 - T_1)\ C_1}$$

Where:

TC = temperature coefficient in ppm/°C.
C_1 = capacitance at 25°C in pF.
C_2 = capacitance at test temperature in pF.
T_1 = 25°C.
T_2 = test temperature in degrees C.

4.7.22 Life (see 3.25).

4.7.22.1 2,000-hour (qualification inspection). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exceptions shall apply:

(a) Distance of temperature measurements from specimens, inches - Not applicable.
(b) Test temperature and tolerance - At the applicable high-test temperature, $^{+4°}_{-0°}$C (see 3.1).
(c) Operating conditions - Capacitors shall be subjected to 140 percent of the rated dc voltage. When necessary, a suitable current-limiting resistor shall be used.
(d) Test condition letter - F (see table C15).
(e) Measurements during and after exposure - At the conclusion of the test, the capacitors shall be returned to the inspection conditions specified in 4.3 and shall be visually examined for evidence of mechanical damage and obliteration of marking; insulation resistance at +25°C, capacitance, and dissipation factor shall be measured as specified in 4.7.9, 4.7.10, and 4.7.11, respectively.

TABLE C15. Life test in hours.

NON-ER capacitors			
Characteristic	Qualification	Group B	Group C
E, F, or K	240^{+48}_{-0}	240^{+48}_{-0}	---
K or N	240^{+48}_{-0} 1/	240^{+48}_{-0} 1/	---
M	$2{,}000^{+72}_{-0}$	240^{+48}_{-0}	$1{,}760^{+72}_{-0}$
P	240^{+48}_{-0}	240^{+48}_{-0}	---
Q	240^{+48}_{-0}	240^{+48}_{-0}	---

4.7.22.2 Hours (quality conformance inspection).

4.7.22.2.1 240-hour (group B *inspection*) (see 3.25). Capacitors shall be tested as specified in 4.7.22.1, except the duration of the test shall be 240^{+48}_{-0} hours.

4.7.22.2.2 2,000-hour (group C inspection) (see 3.25). Except as specified in the following, capacitors shall be tested as specified in 4.7.22.1:

(a) Test duration - See table C15.

(b) Measurements during and after exposure - Measurements, as specified in 4.7.22.1 (e), shall be taken at the following intervals of exposure: During the first hour, 240^{+48}_{-0}, $1{,}000^{+48}_{-0}$, and $2{,}000^{+72}_{-0}$.

4.7.22.3 Extended life (see 3.25).

4.7.22.3.1 Following 2,000-hour qualification inspection. Sample units that have been subjected to 2,000 hours of life test as specified in 4.7.22.1 and 4.7.22.2.2, shall remain on test for an additional $4{,}000^{+72}_{-0}$ hours. After completion of the 6,000-hour life test time, capacitors shall be measured as specified in 4.7.22.1(e).

4.7.22.3.2 Following 240-hour group B inspection (ER parts only) (see table C15). Sample units that have been subjected to 240 hours of life test as specified in 4.7.22.2.1, shall remain on test for an additional 5,760 hours. Measurements, as specified in 4.7.22.1(e), shall be taken at the following intervals of exposure: After 240 $^{+48}_{-0}$, 1,000 $^{+48}_{-0}$, 2,000 $^{+72}_{-0}$, 4,000 $^{+72}_{-0}$, and 6,000 $^{+72}_{-0}$ hours.

4.7.22.3.3 Following 240-hour group B inspection (non-ER parts, characteristic M only, see table C15). Every 3 months, 12 sample units that have successfully completed the 240-hour group B life test, shall be continued on test for an additional 1,760 $^{+72}_{-0}$ hours.

4.7.23 Fungus (see 3.26). Capacitors shall be tested in accordance with method 508 of MIL-STD-810. Pretest and post-test measurements are not required.

4.7.24 Resistance to solvents (see 3.27). Capacitors shall be tested in accordance with method 215 of MIL-STD-202. The following details shall apply:

(a) Portion of specimen to be brushed - That portion on which marking is present.
(b) Number of specimens to be tested - As specified in applicable inspection tables.
(c) Permissible extent of damage - As specified in 3.27.

4.7.25 Resistance to soldering heat (see 3.28) (applicable to wire-lead capacitors only). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details shall apply:

(a) Depth of immersion in the molten solder - To a minimum of 0.250 inch from the capacitor body.
(b) Test condition letter - B ($260^{\circ} \pm 5^{\circ}C$; 10 ± 1 seconds).
(c) Cooling time prior to measurement after test - 10 ± 1 minutes.

4.7.26 Flashpoint of impregnant or filling compound (see 3.29). The flashpoint of impregnant or filling compound shall be measured as specified in

ASTM D92-57, except that the fire point and precision do not apply. "Impregnant or filling compound" shall be substituted for the word "oil" throughout the test method.

4.7.27 Containment. With ten identical characteristic N capacitors connected in parallel, increase the dc terminal voltage until one of the paralleled capacitors fails internally. The number of paralleled capacitors may be reduced as the voltage is increased provided the energy stored in the remaining paralleled capacitors is at least as much as that for the ten paralleled capacitors at rated voltage. Performance of the failed capacitor shall be per 3.5.5.1. The other capacitors in parallel with the failed capacitor shall not be damaged.

4.7.28 Partial discharges (see 3.32). Capacitors shall be tested in accordance with ASTMD1868, (Circuit, Figure 1). The detector used shall have a sensitivity of less than 1.0 picocoulomb before it is loaded with the test specimen. The detector shall have a uniform frequency response up to 500 kiloherz. A liquid or gas filled unit may be tested at any angle of inclination unless an angle is specified (see 3.1 and 6.1.2). The following details shall apply:

(a) Magnitude of test voltage - 100%;
(b) Nature of potential-dc.
(c) Duration of application of test voltage-partial discharges shall be measured for 60 minutes after operating voltage is attained. Voltage shall be increased from 0 to operating test voltage at rate of 500 volts per second.
(d) Points of application of test voltage-as specified in table XIII.
(e) Examination after test-capacitors shall be visably examined for evidence of breakdown, arcing, or other visable damage.
(f) Partial discharges shall not exceed more than one discharge per minute above 10 pc. Partial discharges greater than 1000 pc are unacceptable. Partial discharges within the capacitor shall be calculated per ASTM D1868 or ASTM D3382-75.

4.7.29 Impulse Voltage (see 3.33). Capacitors shall be tested with a basic insulation level surge voltage (BIL) according to the AIEE-EEI-NEMA Standard Basic Insulation Levels, NEMA Publication No. 109, dated January 1941 to the value shown in table C16. The BIL shall be in accordance with the following definition:

> "Basic impulse insulation levels are reference levels expressed as impulse crest voltage with a standard wave not longer than 1 ½ x 40 microseconds (1½ microseconds rise and 40 microseconds decay, Figure C2). Apparatus insulation as demonstrated by suitable tests shall have capability equal to, or greater than, the basic insulation level."

The BIL levels upon which the capacitors shall be tested are given in table C16.

TABLE C16. Basic insulation level voltages.

Voltage Rating KV Crest	Maximum Operating Voltage (Crest)	Impulse Withstand Voltage (Crest)
12.5	12.5	50
15	15	60
25	25	100
50	50	200
75	75	300
100	100	400
125	125	450
150	150	550
175	175	600
200	200	650
250	250	800
300	300	900

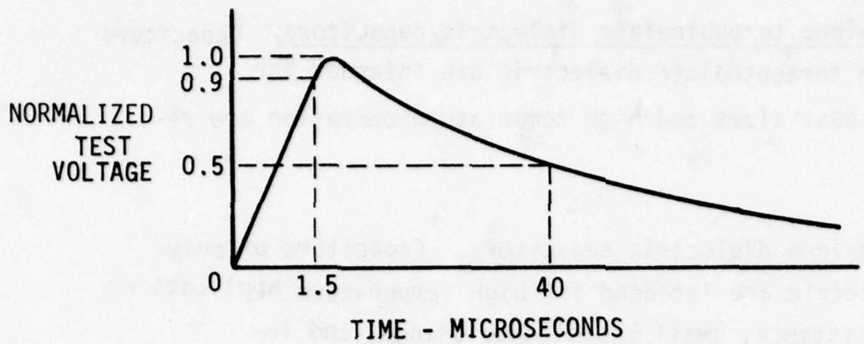


FIGURE C2. Basic insulation level test voltage profile

5. PREPARATION FOR DELIVERY

5.1 Capacitors shall be prepared for delivery in accordance with MIL-C-39028. In addition to any special marking required by MIL-C-39028 or the contract or purchase order (see 6.2), each unit package shall be marked as specified in MIL-STD-1285.

6. NOTES

6.1 Intended use.

6.1.1 Polystyrene dielectric capacitors. Capacitors of polystyrene dielectric, because of their low dielectric absorption and radiofrequency losses, are intended primarily for use in calculators, computers, integrators, time-base oscillators, laboratory standards, and other pulse applications. The outstanding characteristics of these capacitors are low temperature coefficient and stability.

6.1.2 Polyethylene terephthalate dielectric capacitors. Capacitors of polyethylene terephthalate dielectric are intended for use in high temperature applications similar to those served by hermetically sealed paper capacitors, but where higher insulation resistance at the upper temperature limits is required.

6.1.3 Paper and polyethylene terephthalate dielectric capacitors. Capacitors of paper and polyethylene terephthalate dielectric are intended for applications where small case sizes and high temperature operation are required.

6.1.4 Polytetrafluoroethylene dielectric capacitors. Capacitors of polytetrafluoroethylene dielectric are intended for high temperature applications where high insulation resistance, small capacitance change, and low dielectric absorption are required. These capacitors exhibit excellent insulation resistance values at high temperatures.

6.1.5 Polycarbonate dielectric capacitors. Capacitors of polycarbonate dielectric are especially suitable for use in tuned circuits and precision timing due to their capacitance stability and minimum capacitance change with temperature.

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Title, number, and date of the applicable specification sheet and the complete part number (see 1.2. and 3.1).
(c) Whether removable mounting retainers are to be supplied with capacitors (see 3.1).
(d) If remarking of parts is required to indicate FR level (see 3.30.5).
(e) Special marking, if required (see 5.1).

6.3 Definitions.

6.3.1 Liquid-impregnated capacitor. A liquid-impregnated capacitor is a capacitor in which a liquid impregnant is dominantly contained within the capacitor element, but does not occupy substantially all of the case volume not required by the capacitor element and its connection.

6.3.2 Liquid-filled capacitor. A liquid-filled capacitor is a capacitor in which a liquid impregnant occupies substantially all of the case volume not required by the capacitor element and its connections. Space may be allowed for the expansion of the liquid with temperature variations.

6.3.3 Nonmagnetic case capacitor. A nonmagnetic case capacitor is a capacitor in which no part of the case or retainer is made of magnetizable material; however, the end seal may be made of a material having a ferrous metal content in order to effect a glass-to-metal seal.

6.3.4 Hermetic seal. For the purpose of this specification, a hermetically sealed capacitor is one in which the capacitive element is contained within a sealed enclosure of ceramic, glass or metal, or combinations thereof, where sealing is accomplished by material fusion, welding, brazing or soldering. The capacitor shall be capable of passing the seal test specified in 4.7.6 or of meeting a leak-rate requirement of not more than 1.76×10^{-6} cubic centimeters (cm^3) per second, when determined by any other method having sensitivity equal to or better than the stated limit. When capacitors are tested as specified in 4.7.6, there shall be no continuous visible stream of bubbles.

6.4 Qualification. 2/ With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids qualified for inclusion in the applicable qualified products list whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible

2/ SD-6, "Provisions Governing Qualification," is issued for the information of applicants requesting qualification of product. Copies of this publication may be obtained from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

for the qualified products list is the Air Force, Code 80, FSG 59, Directorate of Engineering and Technical Support Branch, SMAMA (MMRE), Wright-Patterson AFB, Ohio 45433. However, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-EQ), 1507 Wilmington Pike, Dayton, Ohio 45444.

6.5 Application information.

6.5.1 Mounting. Capacitors covered by this specification shall be mounted by a retainer or clamp or should be potted when vibration or shock are likely to be encountered in service.

6.5.2 Voltage derating with temperature (for characteristic M). Characteristic M tubular capacitors may be used in applications up to 125°C with voltage derating as indicated in figure C3. However, insulation resistance requirements at 125°C cannot be expected to exceed 100 megohms; greater capacitance change may be encountered, and life expectancy of the unit will be reduced.

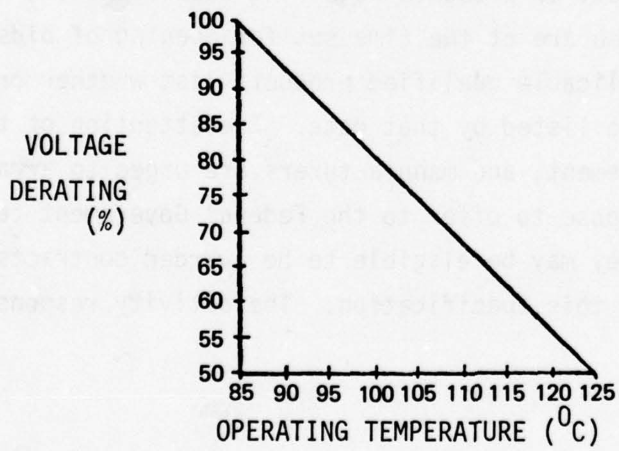


Figure C3. Intended operating temperature.

6.5.3 Energy content (in watt-seconds). The energy content of a fully charged dc capacitor is determined by the following formula:

$$W = \frac{CE^2}{2}$$

Where:

W = energy content in watt-seconds.

C = nominal capacitance in farads.

E = dc voltage rating in volts.

6.5.4 AC component. The rating given is the steady-state dc voltage, or the sum of the dc voltage and the peak ac voltage, provided that the peak ac voltage does not exceed 20 percent of the rating at 60 Hz, 15 percent at 120 Hz, or 1 percent at 10,000 Hz. Where heavy transient or pulse currents are encountered, the requirements of this specification are not sufficient to guarantee satisfactory performance, and due allowance must therefore be made in the selection of a capacitor.

6.5.5 Barometric pressure (reduced) (see 4.7.8).

6.5.5.1 Ceramic- or glass-cased tubular capacitors. The dc voltage that may be applied to ceramic- or glass-cased tubular capacitors at altitudes from 50,000 to 100,000 feet may be obtained from figure C4. The voltage shall be limited to 1000 VDC unless otherwise specifed.

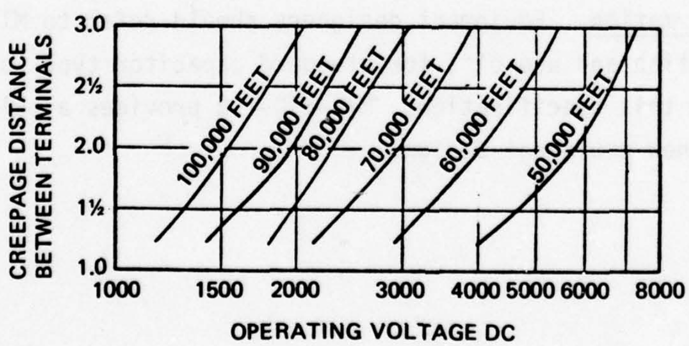


Figure C4. Permissible operating voltage at altitudes from 50,000 to 100,000 feet.

6.5.5.2 Metal-cased tubular capacitors. The dc voltage that may be applied to metal-cased tubular capacitors at altitudes other than 80,000 feet may be obtained from figure C5, except that the dc voltage rating must not be exceeded.

6.5.6 Representation of minimum insulation-resistance requirements. A graphical representation of minimum insulation-resistance requirements, as specified in the applicable specification sheet, is shown in figure C6.

6.5.7 Life at temperatures and voltages below and above rated. The failure rates used in this specification are referred to operation at rated voltage at the maximum rated temperature. The sampling plans and failure-rate determinations throughout the specification assume an acceleration factor of 5 for the life test conducted at the maximum rated temperature and 140 percent of rated voltage. Lower failure rates than those for which the manufacturer has obtained qualification may be achieved by operating the capacitors at lower voltage, or at lower temperatures, or both. Factors by which failure rates are to be multiplied under conditions other than maximum conditions are shown on figure C7(characteristic K only).

6.5.8 Temperature rise. Minimum insulation resistance of characteristic N capacitors shall be great enough to cause temperature rise to $5^{O}F$ maximum when the capacitor is operated at rated voltage in a 50,000 ft pressure altitude, rated temperature environment.

6.6 Selection and use information. Equipment designers should refer to MIL-STD-198, "Capacitors, selection and use of", for standard capacitor types and selected values chosen from this specification. MIL-STD-198 provides a selection of standard capacitors for new equipment design.

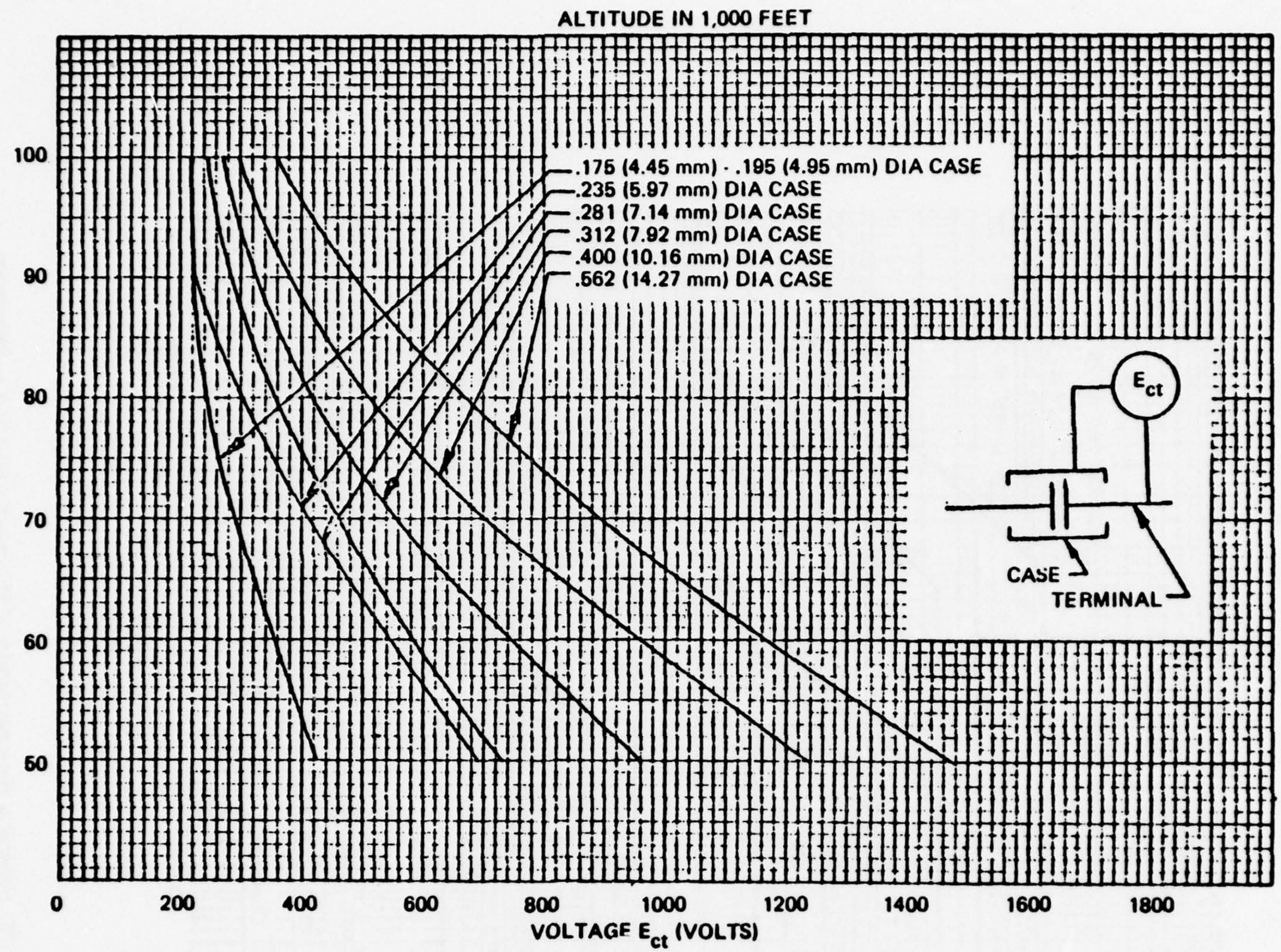


Figure C5: Permissible Operating Voltage at Altitudes other than 80,000 Feet (Metal-Cased Tubular)

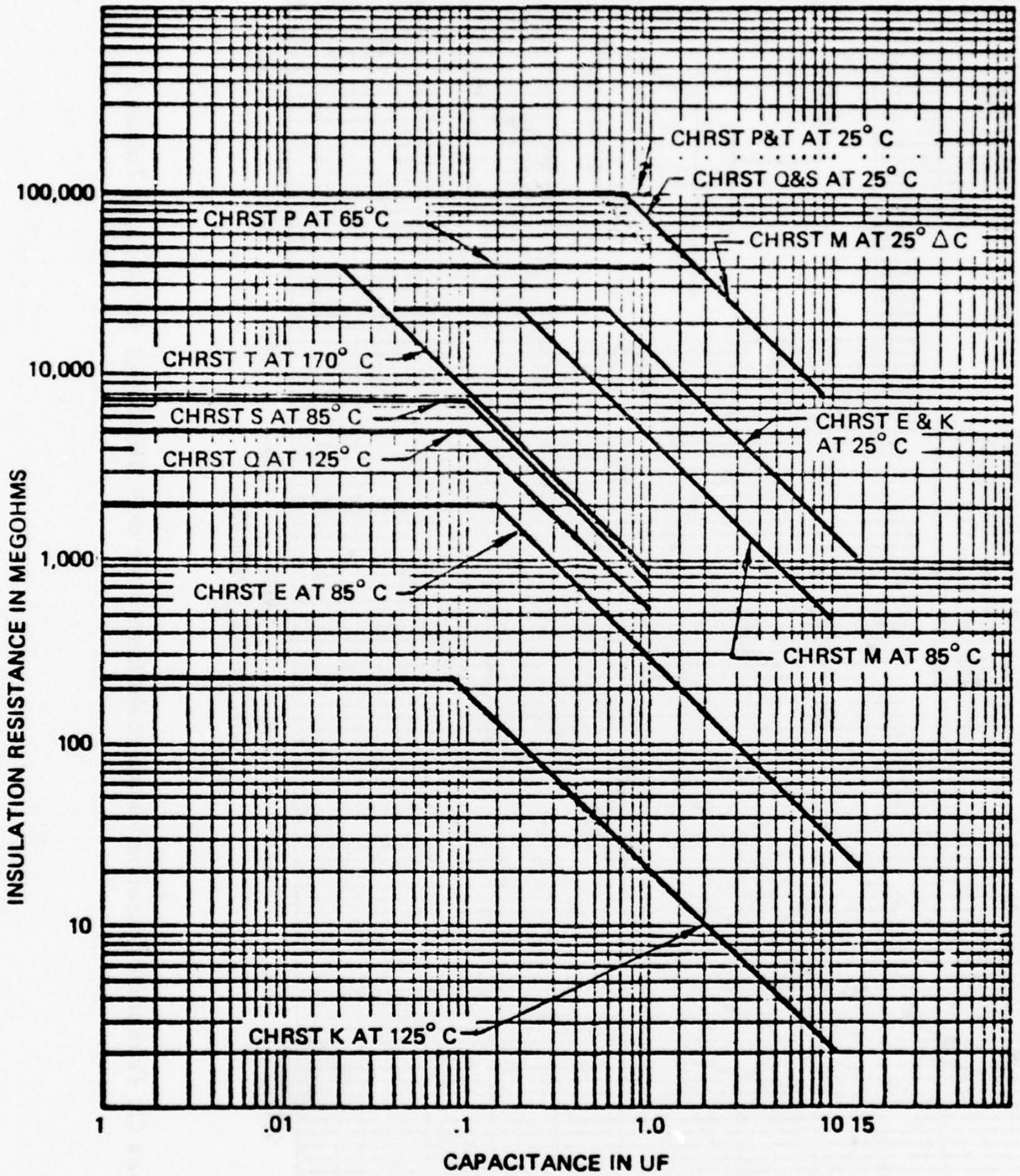
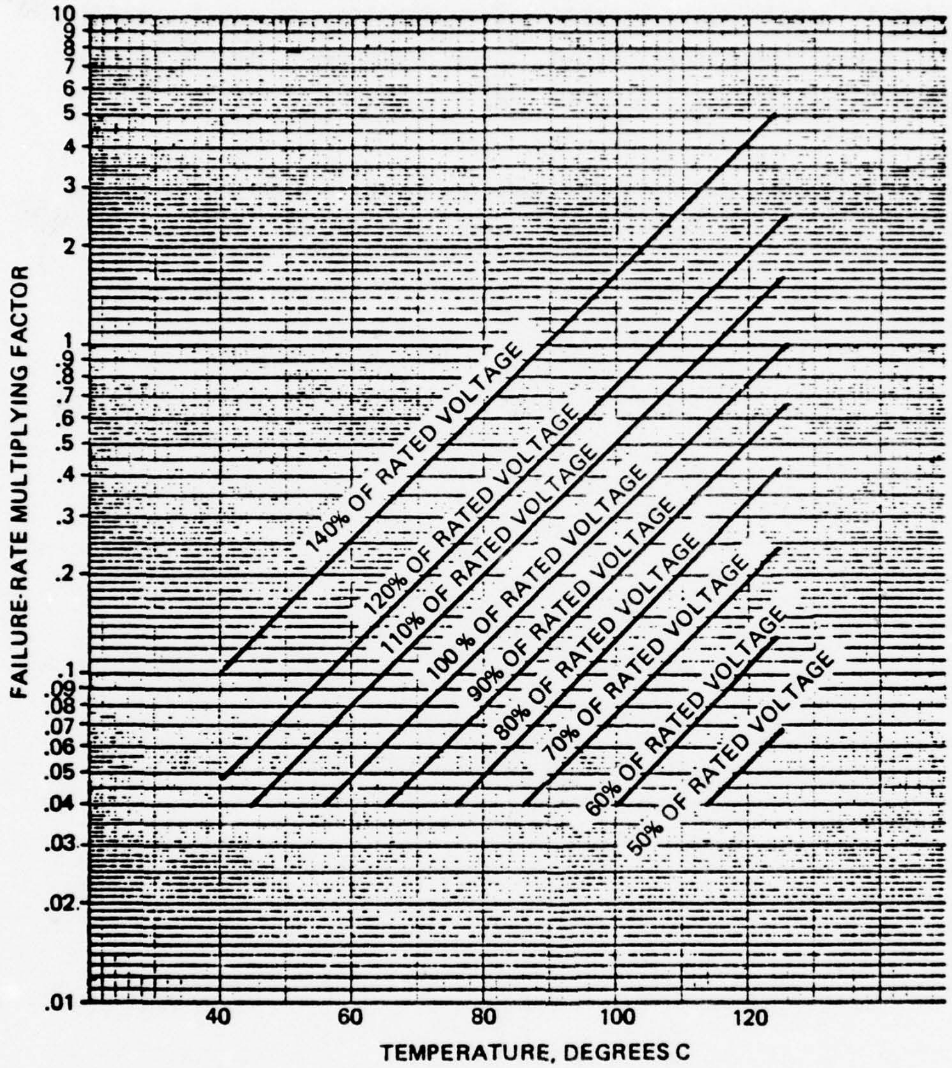


Figure C6: Graphical Representation of Minimum Insulation – Resistance Requirements by Dielectric as Specified in the Applicable Specification Sheet



NOTE : CURVES FOR 100 PERCENT OF RATED VOLTAGE AND HIGHER ARE BASED ON THE 5TH POWER RULE AND CURVES FOR 90 PERCENT OF RATED VOLTAGE AND BELOW ARE BASED ON THE 4TH POWER RULE.

Figure C7: Life at Temperature and Voltages Relative to Percent Rating (Characteristic K Only)

6.7 Interchangeability and substitutability. Whenever possible, items covered by this specification shall be used to replace items covered by MIL-C-14157, "Capacitors, fixed, paper (paper-plastic) or plastic dielectric, direct current (hermetically sealed in metal cases) established reliability, general specification for" and MIL-C-25, "Capacitors, fixed, paper-dielectric, direct current (hermetically sealed in metal cases) general specification for."

6.8 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

10. PROCEDURE FOR QUALIFICATION INSPECTION

10.1 This details the procedure for submission of samples, with related data, for qualification inspection of capacitors and retainers covered by this specification. The procedure for extending qualification of the required sample to other capacitors and retainers covered by this specification is also outlined herein.

20. SUBMISSION

20.1 Single-type capacitor submission. The following details apply:

(a) Sample size - As specified in table C8.

(b) Sampling criteria - Sample units of the same style, terminal, circuit, characteristic, rated voltage, capacitance, capacitance tolerance, and vibration grade will be submitted.

(c) Extent of qualification:

(1) Circuit diagram 1 will qualify circuit diagram 3 in the same capacitor design.

(2) Qualification in one characteristic does not constitute qualification in any other characteristic.

(3) Capacitance tolerance, F (Table C5), may represent all other authorized capacitance tolerances.

(4) Vibration grade 3 will qualify vibration grade 1 provided that the designs of the capacitors are the same.

(5) Qualification of insulated styles will be the basis for qualification of uninsulated styles of the same design.

(6) Qualification of ER styles will qualify applicable non-ER styles of the same characteristic, voltage rating, and case size.

(7) Qualification approval granted for one of the lower failure rate levels will include qualification approval for all of the higher failure rate levels.

20.1.1 Single type retainer submission. The following details apply:

(a) Sample size - As specified in table C9.

(b) Sampling critera - Sample units of the same retainer designator, design and case size will be submitted.

(c) Extent of qualification - Qualification will be limited to the part number submitted.

20.2 Combined type retainer submission. The following details apply:

(a) Sample size - Six retainers shall be submitted.

(b) Sampling criteria - Retainers submitted may be divided between the largest and smallest sizes in the footed and spaded design as shown in table C9 or in the designs in the largest and smallest case size required for complete qualification.

(c) Extent of qualification - Either submission of (b) above will confer eligibility for complete qualification of brackets.

20.3 Impregnant or filling compound. A minimum of 1/4 pound of each impregnant or filling compound used in the sample units for which qualification is sought shall be submitted.

30. DATA REQUIREMENTS

30.1 Test data. When examinations and tests are to be performed at a Government laboratory, prior to submission, all sample units shall be subjected to all of the examinations and tests indicated as nondestructive in table C8. Each submission shall be accompanied by the test data obtained from these examinations and tests. The performance of the destructive examinations and tests by the supplier on a duplicate set of sample units is encouraged, although not required. All test data shall be submitted in duplicate.

30.2 Description of items. The supplier shall submit a detailed description of the materials and constructional features of the capacitors being submitted for inspection, including information as to whether they are liquid impregnated or liquid filled; the type and quantity of the impregnant or filling compound; the type, thickness, and number of layers of capacitor dielectric material and foil; the material, thickness, and applied finish of the case; and details on the end seal and terminal assembly.

30.3 Certification of materials. The supplier shall submit certification, in duplicate, that the materials used in his components are in accordance with the applicable specification requirements.

40 CAPACITORS, HIGH VOLTAGE, FIXED, PLASTIC (OR PAPER-PLASTIC) DIELECTRIC SEALED IN METAL CASES, STYLE CQ72

This specification is approved for use by all Departments and Agencies of the Department of Defense.

40.1 Scope

The complete requirements for procuring the capacitors described herein shall consist of this document and the latest issue of Specification MIL-C-19978.

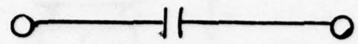
Symbol	Type of terminal
D	Pillar insulator (for use at altitudes up to 7,500 feet)
E	Pillar insulator (for use at altitudes up to 50,000 feet)
J	Bushing insulator with corona protected terminal
K	High voltage connector per MIL-C-5015 (modified)

Terminal number	Terminal symbols	Terminal dimension			
		V, max	Y, min	Y, max	Z
1	B	.75			.812

40.2 REQUIREMENTS:

40.2.1 Design and construction:

Dimensions and configuration - See figure C8 and table C19.
Construction - Extended foil or laid-in tab.
Case and retainer material - Metal, nonmagnetic or magnetic.
Dielectric material - Paper and polyethylene terephthalate.
Terminals - See figures C8 and C9.
Circuit diagram -



Rated voltage - See table C18.
Rated temperature - -65° to $+85^{\circ}$C (E)
-65° to $+125^{\circ}$C (K)
-55° to $+85^{\circ}$C (F and G).
Capacitance (cap.) (non) - See table C18.
Capacitance tolerance - (± 10 percent).
Vibration grade - See table C18.
Dissipation factor (DF) (max) - 1.0 percent.

40.2.2 Seal: Method 112 of MIL-STD-202, test condition letter - A, or in accordance MIL-C-19978 (alternative test).

40.2.3 Barometric pressure: In accordance with MIL-C-19978; terminal D capacitors not applicable.

Test condition letter - B (3.44 inches of mercury - 50,000 feet).
Test points - Between ungrounded terminal and case.
Test potential - 125 percent of dc rated voltage.

40.2.4 Insulation resistance (IR):

Terminal to terminal - See table C17.
Terminals to case - Greater than 10,000 megohms.

40.2.5 Vibration, high frequency: Method 204 of MIL-STD-202, test condition B, with the following exception:

Direction and duration of motion - 4 hours in each of two mutually perpendicular directions (total of 8 hours), one parallel and the other perpendicular to the cylindrical axis.

40.2.6 Salt spray: In accordance with MIL-C-19978.

40.2.7 Solderability: Not applicable.

40.2.8 Terminal strength: Method 211 of MIL-STD-202, test condition letters - A and E.

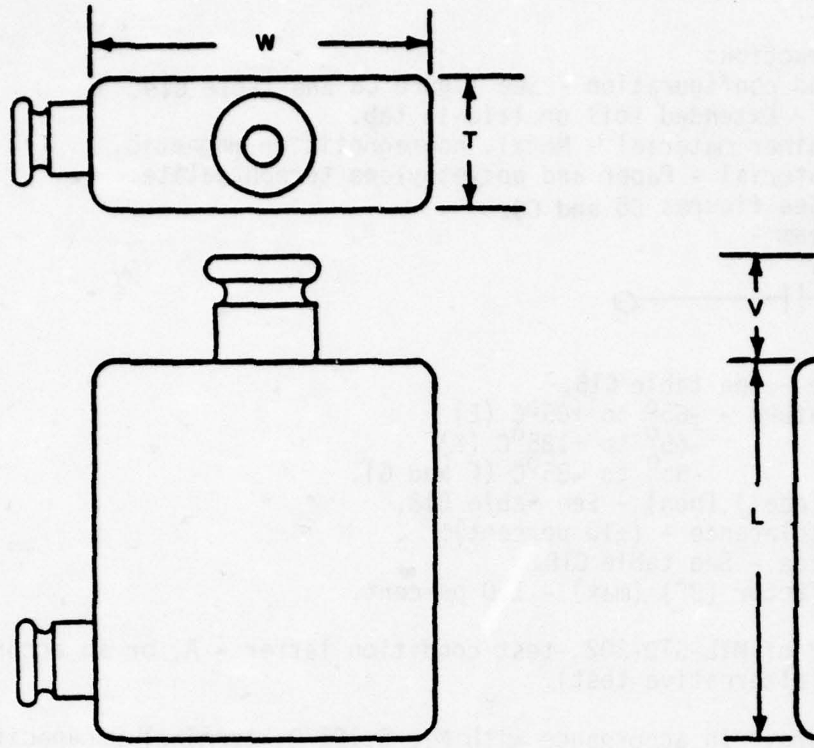


Figure C8: Style Capacitors

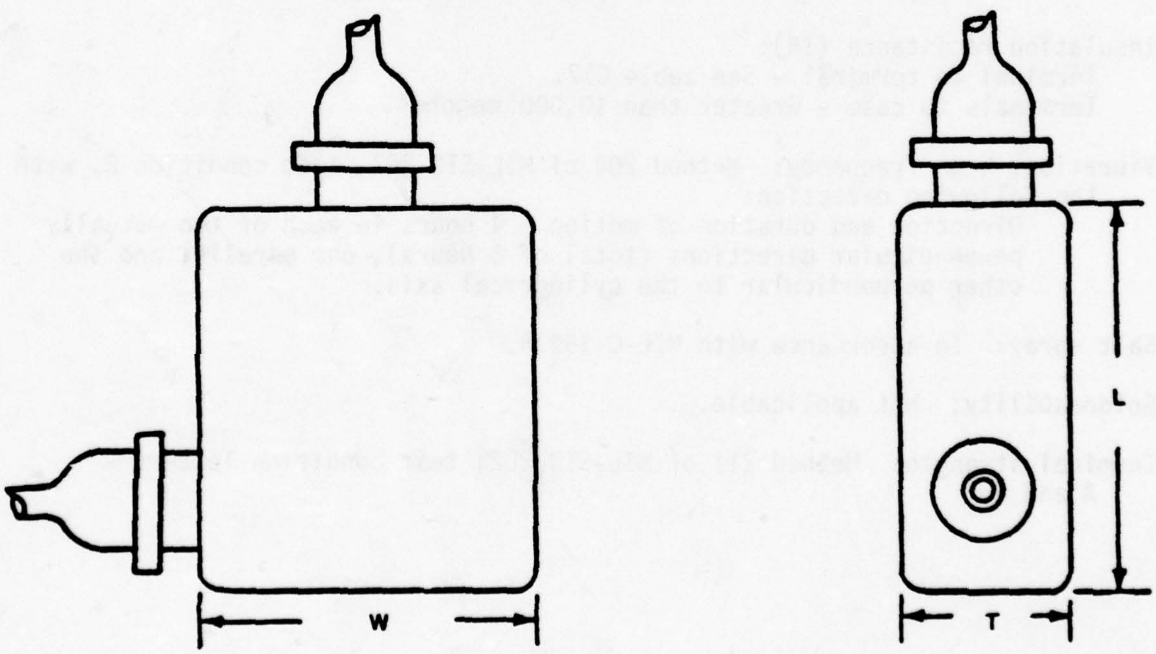


Figure C9: Style Capacitors

40.2.9 Stability at low and high temperatures:

Low temperature:

Test temperature - $-55^{\circ}{}^{+0^{\circ}}_{-5^{\circ}}$C (F and G) or $-65^{\circ}{}^{+0^{\circ}}_{-5^{\circ}}$C (E and K).

Capacitance change (max) - (-10 percent).

High temperature:

Test temperature - $+85^{\circ}$C (E, F, and G) or $+125^{\circ}$C (K).

Capacitance change (max) - (+10 percent).

40.2.10 Life:

Capacitance change (max) - (±5 percent).

Resistance to soldering heat: Not applicable.

Table C17. Terminal-to-terminal insulation resistance.

Capacitance rating	Minimum insulation resistance
Characteristic E	At 25°C
0 to 0.6 microfarad - - - - - - - - - - - - - - -	25,000 megohms
Greater than 0.6 microfarad - - - - - - - - - -	15,000 megohm-microfarads 1/
	At 85°C
0 to 0.15 microfarad - - - - - - - - - - - - - -	2,000 megohms
Greater than 0.15 microfarad - - - - - - - - -	300 megohm-microfarads 1/
Characteristic K	At 25°C
0 to 0.6 microfarad - - - - - - - - - - - - - - -	25,000 megohms
Greater than 0.6 microfarad - - - - - - - - - -	15,000 megohm-microfarads 1/
	At 125°C
0 to 0.08 microfarad - - - - - - - - - - - - - -	250 megohms
Greater than 0.08 microfarad - - - - - - - - -	20 megohm-microfarads 1/
Characteristic F	At 25°C
0.33 microfards, and less - - - - - - - - - - -	6,000 megohms
Greater than 0.33 microfarads - - - - - - - - -	2,000 megohm-microfarads 1/
	At 85°C
0.033 microfarads and less - - - - - - - - - -	600 megohms
Greater than 0.033 microfarads - - - - - - - -	20 megohm-microfarads 1/
Characteristic G	At 25°C
0.33 microfarads and less - - - - - - - - - - -	4,500 megohms
Greater than 0.33 microfarads - - - - - - - - -	1,500 megohm-microfarads 1/
	At 85°C
0.33 microfarads and less - - - - - - - - - - -	450 megohms
Greater than 0.033 microfarads - - - - - - - -	15 megohm-microfarads 1/

1/ Product obtained by multiplying the capacitance in microfarads by the insulation resistance in megohms.

Table C18. Style capacitors.

Part number	DC voltage rating	Capacitance	Vibration grade	Case size				Available terminal identification number		
				Characteristic				Terminal		
				E	K	F	G	B	D	E
	Volts	μF								

Table C19. Case dimensions and retainer part number.

Case size	Case dimensions (in inches)				Retainer part number
	W ±.062	T ±.062	L ±.062	A +.0625 -.187	

Table C20. Millimeter equivalent of decimal inches.

INCHES	MM	INCHES	MM	INCHES	MM
.015	.38	2.281	57.94	5.500	139.70
.016	.41	2.375	60.33	5.750	146.05
.025	.51	2.500	63.50	5.875	149.23
.031	.79	2.625	66.68	6.000	152.40
.045	1.14	2.719	69.06	6.250	158.75
.047	1.19	2.750	69.85	6.375	161.93
.062	1.57	2.875	73.03	6.500	165.10
.0625	1.59	3.000	76.20	6.750	171.45
.094	2.39	3.062	77.77	6.875	174.63
.125	3.18	3.125	79.38	7.000	177.80
.187	4.75	3.188	80.98	7.250	184.15
.188	4.78	3.250	82.55	7.375	187.33
.213	5.41	3.375	85.73	7.500	190.50
.281	7.14	3.500	88.90	7.750	196.85
.391	9.93	3.625	92.08	8.000	203.20
.438	11.13	3.656	92.86	8.250	209.55
.625	15.88	3.750	95.25	8.375	212.73
.812	20.62	3.812	96.82	8.500	215.90
.844	21.44	3.875	98.43	9.000	228.60
.906	23.01	3.938	99.03	9.250	234.95
1.062	26.97	4.000	101.60	9.375	238.13
1.125	28.58	4.125	104.78	9.500	241.30
1.188	30.18	4.250	107.95	9.625	244.48
1.250	31.75	4.375	111.13	10.125	257.18
1.344	33.14	4.500	114.30	10.375	263.53
1.375	34.93	4.562	115.87	10.750	273.05
1.469	37.31	4.625	117.48	11.000	279.40
1.625	41.28	4.750	120.65	11.250	285.75
1.750	44.45	4.844	123.04	12.625	320.68
1.812	46.02	4.875	123.83	12.875	327.03
1.938	49.13	4.969	126.21	13.125	333.38
1.967	49.96	5.000	127.00	13.500	342.90
2.000	50.80	5.094	129.39	13.750	349.25
2.062	53.37	5.125	130.18	15.625	396.88
2.125	53.98	5.250	133.35	16.750	425.45
2.250	57.15	5.375	136.53		

NOTES:

1. Dimensions are in inches.
2. Shape of retainer optional provided specified dimensions are met. Spade lugs shall be rigid and double welded, double riveted, single riveted and soldered, or welded and single riveted to the retainer.
3. Minimum thickness of retainers shall be .045 (1.14mm).
4. When two part numbers are applicable to the same retainer, both part numbers shall be marked on the retainer. Retainers shall be marked on the outer surface.
5. When used, rivets shall curl-over .020 (.51mm) ±.015 (.38mm) beyond the inside of the retainer.

APPENDIX D

CONNECTORS

CONNECTORS, ELECTRICAL,
GENERAL SPECIFICATION FOR

1. SCOPE

1.1 Scope. This specification covers circular electrical connectors with a single solder or brazed contact. These connectors are for use in airborne high voltage electrical power systems (see 6.1).

1.1.1 Temperature. These connectors are rated for specified operation within a temperature range of -65°C (-85°F) to either 125°C (257°F), 175°C (347°F), or 200°C (392°F) depending upon the class. The upper temperature is the maximum internal hot-spot temperature resulting from any combination of electrical load and ambient conditions.

1.1.2 Service Life. These connectors are to meet the specified requirements for a service life of 1750 operating hours at high voltage.

1.2 Classification. Electrical connectors shall be of the following sizes, types, and styles as specified (see 6.1).

1.2.1 Types

1. Receptacle
   - Style A - Straight
   - Style B - Right Angle
2. Plug
   - Style A - Straight
   - Style B - Right Angle

1.2.2 Sizes

No. 16-16
No. 12-12
No. 8-8
No. 4-4
No. 0-0

1.2.3 Coupling. Connectors shall have threaded couplings torqued to proper pressure with spanner wrenches and locked in place with wire seals.

1.2.4 Receptacle Mounting. Receptacle mounting shall be designated as follows:

Flange

Jam Nut

1.3 Wire range accommodations. The wire ranges given in table D-1 shall be accommodated by the connectors as indicated.

TABLE D-1 Wire range accommodations

Contact Size	Wire Size	OD of finished wire (inch) Min	Max
16-16	20 18 16	0.064	0.130
12-12	14 12	0.114	0.170
8-8	10 8	0.164	0.255
4-4	6 4	0.272	0.370
0-0	2 0	0.415	0.550

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein:

SPECIFICATIONS

FEDERAL

- QQ-P-416 - Plating, Cadmium (Electrodeposited).
- QQ-S-365 - Silver Plating, (Electrodeposited), General Requirements for
- QQ-S-571 - Solder, Tin Alloy: Tin-Lead Alloy; and Lead Alloy
- QQ-S-763 - Steel Bars, Wire, Shapes, and Forgings, Corrosion Resisting

MILITARY

MIL-S-7742	-	Screw Threads, Standard, Optimum Selected Series; General Specification for
MIL-C-23216	-	Contacts, Electric Connector, General Specification for
MIL-G-45204	-	Gold Plating, Electrodeposited
MIL-C-45662	-	Calibration System Requirements
MIL-C-55330	-	Connectors, Preparation for Delivery of

STANDARDS

MILITARY

MIL-STD-810	-	Test Methods for Electronic and Electric Component Parts
MIL-STD-454	-	Standard General Requirements for Electronic Parts
MIL-STD-456	-	Electronic Parts, Date and Source Coding for
MIL-STD-1285	-	Marking of Electrical and Electronic Parts
MIL-STD-1353	-	Electrical Connectors and Associated Hardware, Selection and Use of
MS3197	-	Gage Pin for Socket Contact Engagement Test

(See Supplement for list of applicable MS standards.)

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

H28 Handbook	Screw-Thread Standards for Federal Services
ASTM D1868	Detection and Measurement of Discharge (Corona) Pulses in Evaluation of Insulation Systems
NEMA Publication No. 109	AIEE-EEI-NEMA Standard Basic Insulation Level

(Applications for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C. 20360).

3. REQUIREMENTS

3.1 Specification Sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of conflict between the requirements of this specification and the applicable specification sheets, the latter shall govern.

3.2 Qualification. The connectors and accessories furnished under this specification shall be products which are capable of being qualified for listing on the applicable qualified products list (QPL).

3.3 Materials. The material for each part shall be as specified (see 3.1). When a definite material is not specified, a material which will enable the element to meet the requirements of this specification shall be used. Acceptance or approval of a constituent material shall not be construed as a guarantee of the acceptance of the finished product.

3.3.1 Dissimilar Metals. When dissimilar metals are employed in intimate contact with each other in a connector or in a mated pair of connectors, suitable protection against electrolytic corrosion shall be provided as specified in requirement 16 of MIL-STD-454.

3.3.2 Nonmagnetic Materials. All parts shall be made of materials which are classed as nonmagnetic (see 3.3.5).

3.3.3 Contact Materials. Contacts shall be made of suitably conductive materials.

3.3.3.1 Contact Plating.

3.3.3.1.1 Contact Plating (Solder Type). Contacts shall be silver plated in accordance with QQ-S-365 or gold plated in accordance with MIL-G-45204 over silver plating in accordance with QQ-S-365. The resultant minimum thickness of contact plating shall be 100 microinches. Accessory members of the socket contacts need not be plated but shall comply with the requirements for dissimilar metals specified in 3.3.1.

3.3.4 Dielectric Materials.

3.3.4.1 Plug and Receptacle. Insert and receptacle materials shall be high grade dielectric having hardness, electrical, and mechanical characteristics suitable for the purpose intended.

3.3.4.1.1 Plug. The plug mating face shall be a resilient semi-flexible material within a Shore A Durometer range of 35 to 85. The plug shall be a part of the cable assembly and shall be supplied with covers. The plug shall have a female socket and shall include parts such as a cover with a shorting bar between contact and shield.

3.3.4.1.2 Receptacles. A receptacle shall be a unit which is fixed on either the aircraft or electrical/electronic assembly. It shall have one male contact and shall include parts such as a cover as required.

3.3.5 Shells and Coupling Rings. When specified (see 1.2.1), shells and coupling rings shall be made of nonmagnetic corrosion-resisting steel in accordance with QQ-S-763, 300 series classes, or QQ-S-764, 303 series and 203 EZ.

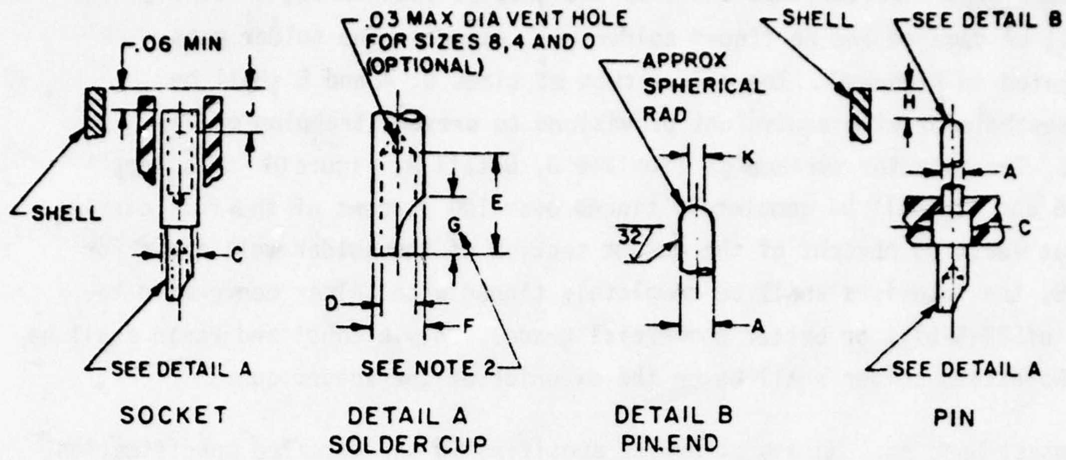
3.3.5.1 Finish. The resultant finish on all connectors shall be electrically conductive. The finish of connectors with corrosion-resistant materials, shells and coupling rings, such as aluminum, shall be cadmium plated in accordance with QQ-P-416, Type 2, Class 3, color-black. All other corrosion-resisting steel connectors shall be passivated. External screws may be stainless steel in lieu of the finish specified.

3.4 Design and Construction. Connectors and accessories shall be designed and constructed in accordance with this specification and the applicable specification sheets, and shall be capable of withstanding normal handling incident to installation and maintenance in service.

3.4.1 Contacts. Contacts shall conform to Figure D-1. Contacts shall be designed so that neither the pin nor socket contact shall be damaged during mating of counterpart connectors. Pin and socket contacts shall have enough tolerance so that gages are not required. The engaging or disengaging force of the contracts shall not exceed 20 pounds, (see 3.20).

3.4.1.1 Plug Mating End. The entering end of the plug socket contact shall be rounded or chamfered to allow for misalignment of the entering pin. The socket contacts shall provide the spring action for maintaining the contacting pressure between the pin and the socket.

3.4.1.2 Receptacle Pin Contacts. Pin contacts shall have their tips finished to a spherical radius, with allowable flat of 1/8 inch less than the pin diameter. The pin contact shall be mechanically held in the receptacle.



Contact size	A 1/ ±.001 Dia	C 2/ Max Dia	D Min Dia	E +.063 -.000	F Dia Min	F Dia Max	H Plug & rcpt Min	H Plug & rcpt Max	J 3/ Max plug and rcpt	K Dia of flat
16	.0625	.127	.069	.250	.096	.116	.250	.312	.281	.032 Max
4/ 16S	.0625	.127	.069	.250	.096	.116	.062	.125	.281	.032 Max
12	.094	.190	.112	.375	.130	.150	.062	.125	.375	.032 Max
8	.142	.310	.205	.500	.243	.259	.062	.125	.375	.032 Max
4	.225	.441	.328	.625	.370	.397	.062	.125	.375	.105 ±.021
0	.357	.597	.464	.625	.510	.550	.062	.125	.281	.237 ±.021

1/ Applies after plating.
2/ Used for calculating mechanical spacing between contacts and between contacts and shell.
3/ Represents the distance from the end of the shell to the point at which the mating pin engages the socket contact spring.
4/ Dimensions shown are typical for shell sizes 8S, 10S, 10SL, 12S, 14S and 16S.

NOTES:
1. Dimensions are in inches.
2. Sizes 12 and 16: G max = 2/3 E, radius of cutout optional.
Sizes 0, 4, and 8: Cutout optional.

FIGURE D-1 SOLDER CONTACT (PIN AND SOCKET) CONFIGURATION

3.4.1.3 Solder Cups. Solder cups shall be designed so that during soldering no components will be damaged and no liquid solder will escape. The solder cups shall be as indicated in Figure D1. The solder cups of sizes 0, 4, and 8 shall be provided with a venthole or with equivalent provisions to prevent trapping of air during soldering. The interior surface of (Surface D, Detail A, Figure D1 of solder cups for sizes 16 and 12 shall be completely tinned over 100 percent of the full circle portion and for at least 50 percent of the cutout section of the solder well area; for sizes 0, 4, and 8, the interiors shall be completely tinned with solder conforming to composition Sn60 of QQ-S-571, or better commercial grade. Only alcohol and resin shall be used as a flux. No excess solder shall be on the exterior of the solder cup.

3.4.1.4 Contact Spacing. Unless otherwise specified in the detailed specification, minimum mechanical spacing and creepage distance shall be as shown in Table D2.

TABLE D2. MINIMUM CONTACT SPACING

Service Rating KV	Minimum contact spacing (inch) Contact to Shell[1]
10	0.5
20	1
50	2
100	4
150	6
200	8

(1) Distance is total surface distance from contact to shell.

3.4.1.5 Contact Alinement. Inserts for socket contacts shall provide an overall sideplay of the socket contacts of 0.005 to 0.015 inch from the required position to facilitate alignment of mating pin contacts.

3.4.2 Plug and Receptacle Insulation. Plugs and receptacles shall be of: (a) void free materials in the connector, and (b) free of trapped air when mated.

3.4.2.1 Plug Insulation. Plugs shall be made of non removable, resilient, elastomeric materials molded to the cable. The socket contact shall be mounted on the plug.

3.4.2.1.1 Shield Termination. The shield shall be terminated in a manner to cover all sharp ends to prevent them from emitting electrical discharges.

3.4.2.1.2 Semi Conducting Layer. Cable semi conducting layer under the shield shall be removed to provide adequate distance between the center conductor and the shell/shield termination.

3.4.2.1.3 Molded Configuration. A molding process shall be used to bond the cable primary insulation to the plug insulation. A semi conducting layer may cover the bonded joint to provide a better bonding surface.

3.4.2.2 Receptacle Insulation. Receptacle insulation shall be of a seamless rigid voidless material. A voidless fit shall exist between the shell and the molded insert to eliminate corona. Semiconducting materials may be added to achieve the voidfree configuration. The pin contact shall be mounted in the receptacle.

3.4.2.3 Sharp Corners. Sharp corners shall be eliminated to eliminate electric discharge generators.

3.4.3 Screw Threads. Screw threads intended to mate with parts of another approved manufacturer shall be UNEF, UNF, or NEF, class 2A or 2B, conforming to MIL-S-7742, except that 1-3/4-18 and 2-18 threads shall be UNS class 2A or 2B, conforming to Handbook H-28. Screw threads shall be checked after plating by means of ring and plug gages only, in accordance with Handbook H-28. Slight out-of roundness beyond the tolerances of MIL-S-7742 is acceptable if the threads can be checked without forcing the thread gages. Screw threads may be relieved provided the relief does not interfere with proper performance of the screw threads.

3.4.4 Shell Design. Connector shells shall be seamless and retain their inserts in a positive manner.

3.4.4.1 Lubrication. All internal coupling ring threads shall be coated with a suitable lubricant.

3.4.5 Coupling Connections. Threaded coupling rings shall be knurled, and designed so that the pin and socket contacts shall engage or disengage as the ring is respectively tightened or loosened. The coupling rings of connector plugs shall be captive to the shell.

3.4.5.1 Safety of Coupling Rings. All threaded coupling rings shall be designed for safety wiring. At least two holes shall be provided for shell sizes 14 and smaller, and at least three equally spaced holes for connector sizes 16 and larger. These holes shall be of a diameter sufficient to accommodate 0.032 inch diameter wire.

3.4.5.2 Engagement Seal. Connectors shall contain sealing means so that engaged connectors comply with the requirements specified herein. The design of the seal shall be such that in mated connectors all air paths between adjacent contacts and between contacts and shells are eliminated. There shall be interfacial mating of the engaged connector insert to provide dielectric under compression of 0.010 inch per inch length insert minimum. Connector plus shells with threaded coupling rings shall be provided with a static peripheral seal to ensure shell to shell sealing.

3.5 Intermateability and Interchangeability

3.5.1 Intermateability. Connectors shall be intermateable. When different types of connectors (front or rear release) are used in a mated pair of connectors, the minimum performance requirements (temperature, sealing, etc.) must be met.

3.5.2 Interchangeability. All connectors and accessories having the same specified part number shall be completely interchangeable with each other with respect to installation (physical) and performance (function) as specified herein.

3.6 Disengagement. The axial tension required to separate the plug shell from a receptacle shall be 12 pounds, maximum, when tested in accordance with 4.6.2. A thin film insulating grease may be used to lubricate the plug surface.

3.7 Thermal Shock. There shall be no evidence of damage detrimental to the operation of the connector after being subjected to the temperature extremes in accordance with 4.6.3.

3.8 Contact Retention. The axial displacement of crimp contacts shall not exceed 0.025 inch and contacts shall be retained in their inserts when subjected to the axial loads specified in accordance with 4.6.4.

3.9 Dielectric Withstanding Voltage. Connectors shall show no evidence of breakdown or flashover when subjected to the test voltages and altitudes in accordance with 4.6.5. Corona shall not be considered as breakdown.

3.10 Corona. Connectors shall show no evidence of material deterioration or damage when subjected to the test voltages and altitudes in accordance with 4.6.6.

3.11 Impulse. Connectors shall show no evidence of breakdown or flashover when subjected to the test voltages in accordance with 4.6.7.

3.12 Vibration. Mated connectors shall not be damaged and there shall be no loosening of parts due to vibration. Counterpart connectors shall be retained in full engagement, and there shall be no interruption of electrical continuity longer than 10 microseconds when tested in accordance with 4.6.8.

3.13 Shock. Mated connectors shall not be damaged and there shall be no loosening of parts, nor shall there be an interruption of electrical continuity longer than 10 microseconds during the exposure to mechanical shock when tested in accordance with 4.6.9.

3.14 Humidity. Mated connectors shall withstand 120 percent rated voltage in Table D-3 for at least 5 minutes after being tested in accordance with 4.6.10.

TABLE D-3 Test Voltages After Humidity

Service rating Kilovolts	Test Voltages Kilovolts (Crest)
10	15
20	25
50	60
100	120
150	180
200	240

3.15 Contact Resistance. Contacts in the mated condition shall meet the ambient ($25^{o}C$) contact resistance requirements of MIL-C-23216. The potential drop of contacts shall not exceed 125 mV initially or 200 mV after conditioning when tested in accordance with 4.6.11.

3.16 Durability. Counterpart connectors shall show no mechanical or electrical defects detrimental to the operation of the connector after 500 cycles of mating and unmating in accordance with 4.6.12.

3.17 Corrosion. Connectors shall show no exposure of basis metal caused by corrosion which will affect performance when tested in accordance with 4.6.13.

3.18 Insulation Resistance. The insulation resistance at 25°C (77°F) shall be greater than 500 megohms when tested in accordance with 4.6.14.2.

3.19 Moisture Resistance. Mated connectors with any rear accessory hardware assembled shall maintain an insulation resistance of 100 megohms or greater at 25°C after being subjected to the moisture resistance test in accordance with 4.6.15.

3.20 Contact Engaging and Separating Forces. The socket contact engaging and separating forces shall be within the applicable limits specified in Table D4 when tested in accordance with 4.6.16.

TABLE D4. CONTACT ENGAGEMENT AND SEPARATION FORCES.

Contact mating end size	Minimum separation force (ounces) Minimum diameter MS3197 pin	Maximum average engagement force (ounces) Maximum diameter MS3197 pin	Maximum engagement force (ounces) Maximum diameter MS3197 pin
16	2	33	48
12	3	56	80
8	5	---	160
4	10	---	240
0	15	---	320

3.21 Shell Conductivity. Mated connectors shall be electrically conductive from the plug accessory thread to the receptacle mounting flange or to the accessory thread on the cable connecting plug. The overall dc resistance shall not exceed 0.05 ohms when measured in accordance with 4.6.17.

3.22 Altitude. When tested as specified in 4.6.18, the mated connectors shall meet the corona and voltage breakdown requirement. Any evidence of dielectric breakdown or flashover shall be cause for rejection.

3.23 Random Vibration. When tested as specified in 4.6.19, a current discontinuity of 1 microsecond or more, disengagement of the mated connectors, evidence of cracking, breaking, or loosening of parts shall be cause for rejection.

3.24 Marking. Each connector shall be legibly and permanently marked on the shell or coupling ring in accordance with MIL-STD-1285 and MIL-STD-456.

3.25 Workmanship. Loose contacts, poor molding fabrication, loose materials, defective bonding, damaged or improperly assembled contacts, peeling, or chipping of plating or finish, galling of mating parts, nicks and burrs of metal parts and post molding warpage will be considered adequate basis for rejection of items of quality inferior for the purpose intended.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.1 Test Equipment and Inspection Facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-C-45662.

4.2 Classification of Inspection. The inspection of connectors shall be classified as follows:

a. Qualification inspection.
b. Quality conformance inspection (4.4).

4.2.1 Inspection Conditions. Unless otherwise specified, all inspections shall be performed under any combination of conditions within the following ranges. Any specified condition shall not affect the other two ambient ranges.

Temperature: 15^{o} to $35^{o}C$ (59^{o} to $95^{o}F$).
Relative humidity: 30 to 80 percent.
Barometric pressure: 650 to 800 mm of mercury.

4.3 Qualification Inspection. Qualification inspection shall consist of the examinations and tests performed in the sequence specified in Table D5 on the qualification test samples specified in 4.3.1.

4.3.1 Qualification Samples. Samples of each item for which qualification is desired shall be tested in the sequence specified in Table D5, as applicable. Specific details on preparation of samples shall be as follows: Each connector subjected to qualification testing shall be provided with a counterpart connector for those tests requiring mating assemblies. The counterpart connectors provided for this purpose shall be new, previously qualified connectors or new connectors submitted for qualification testing. Manufacturers not producing mating connectors shall submit data substantiating that tests were performed with approved counterpart connectors.

4.3.1.1 Wire-to-contact assembly. Unless otherwise specified herein, connectors shall be wired with approximately 3 feet of wire as applicable.

4.3.1.2 Solder Contact Connectors. Qualification samples and qualification tests for solder contact connectors shall consist of two complete connector assemblies of receptacles and straight plugs for which qualification is desired, in each shell size, which shall be subjected to the tests of Table D5. Qualification testing of these samples will admit qualification of other shell types. Testing of solder contacts need not be performed if compliance of similar contacts has previously been demonstrated in conjunction with qualification testing of connectors of a different class.

4.3.1.3 Socket Contacts. Fifty of each socket contact size and configuration used in the solder contact connectors for which qualification is desired shall be subjected to the tests of Table D5. Sockets which are not completely assembled prior to installation in the insert may be provided and tested in connectors.

4.3.2 Qualification Rejection. There shall be no failures during any examination or tests of the connectors or accessories submitted for qualification tests. After notification of any failure, the agent responsible for qualification testing (see 6.3.1) shall receive details of corrective action from the manufacturer before initiating any further tests deemed necessary to assure compliance with connector requirements.

TABLE D5 Qualification Inspection for Solder Contact Connectors

Inspection	Requirement Paragraph	Test Paragraph
Visual and mechanical	3.1,3.3,3.4,3.5, 3.24 and 3.25	4.6.1
Disengagement (MS3187 plug only)	3.6	4.6.2
Thermal shock	3.7	4.6.3
Contact retention	3.8	4.6.4
Dielectric withstanding voltage	3.9	4.6.5.1
Corona	3.10	4.6.6
Impulse	3.11	4.6.7
Vibration	3.12	4.6.8.1
Dielectric withstanding voltage	3.9	4.6.5.1
Shock	3.13	4.6.9.1
Humidity	3.14	4.6.10
Dielectric withstanding voltage	3.9	4.6.5.3
Corona	3.10	4.6.6
Contact resistance	3.15	4.6.11
Durability	3.16	4.6.12
Corrosion	3.17	4.6.13
Contact resistance	3.15	4.6.11
Insulation resistance	3.18	4.6.14
Moisture resistance	3.19	4.6.15
Contact engaging and separating forces	3.20	4.6.16
Shell Conductivity	3.21	4.6.17
Altitude	3.22	4.6.18
Dielectric withstanding voltage	3.6.5.2	4.6.5.2
Random vibration	3.23	4.6.19
Visual and mechanical	3.1,3.3,3.4,3.5, 3.24 and 3.25	4.6.1

4.4 Quality Conformance Inspection

4.4.1 Inspection of Product for Delivery. Inspection of product for delivery shall consist of groups A and B inspection.

4.4.2 Inspection Lot. An inspection lot shall consist of all connectors covered by this specification, produced under essentially the same conditions and offered for inspection at one time. In-process controls, unrelated to lot sizes of finished connectors, may be used, provided an equivalent or tighter AQL level is maintained.

4.4.2.1 Group A Inspection. Group A inspection shall consist of the examination of product in accordance with 4.6.1.

4.4.2.1.1 Rejected Lots. If an inspection lot is rejected, the supplier may rework it to correct the defects, or screen out the defective units and resubmit for inspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be kept separate and shall be clearly identified as reinspected lots.

4.4.2.2 Group B Inspection. Group B inspection shall consist of the applicable tests specified in Table D6 and shall be made on the units which have been subjected to and have passed Group A inspection.

TABLE D6. GROUP B INSPECTION

Inspection	Requirement Paragraph	Test Paragraph
Dielectric withstanding voltage	3.9	4.6.5.4
Corona	3.10	4.6.6
Insulation Resistance	3.18	4.6.14.2

4.4.2.2.1 Rejected Lots. If an inspection is rejected, the supplier may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.4.2.2.2 Disposition of Sample Units. Sample units which have passed the group B inspection may be delivered on the contract or purchase order.

4.5 Periodic Inspection. Periodic inspection shall consist of group C. Except where the results of these inspections show noncompliance with the applicable requirements (see 4.5.1.4), delivery of products which have passed group B shall not be delayed pending the results of these periodic inspections.

4.5.1 Group C Inspection. Group C inspection shall consist of the tests specified in Table D7 in the order shown. Group C inspection shall be made on sample units selected from inspection lots which have passed the groups A and B inspection. Group C inspection reports shall be forwarded to the qualifying activity every 18 months as specified in the sampling plan.

4.5.1.1 Sampling Plan. Every 18 months, mated connector sample units which have passed groups A and B inspection shall be subjected to the tests specified in Table D7 . Samples shall be selected in sufficient quantity to provide two samples per applicable test group, as determined by the contact type and the class of the samples to be tested.

TABLE D7 . Group C Inspection

Inspection	Requirement Paragraph	Test Paragraph
Insulation resistance	3.18	4.6.14.2
Dielectric withstanding voltage	3.9	4.6.5.1
Corona	3.10	4.6.6
Contact retention	3.8	4.6.8
Shell conductivity	3.21	4.6.17
Durability	3.16	4.6.12
Moisture resistance	3.19	4.6.15
Humidity	3.14	4.6.10
Corrosion	3.17	4.6.13

4.5.1.2 Failures. If one or more sample units fail to pass group C inspection, the sample shall be considered to have failed.

4.5.1.3 Disposition of Sample Units. Sample units which have been subjected to group C inspection shall not be delivered on the contract or purchase order.

4.5.1.4 Noncompliance. If a sample fails to pass group C inspection, the manufacturer shall take corrective action on the materials or processes, or both, as warranted, and on all units of the product which can corrected and which were

manufactured with essentially the same materials, processes, etc. and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the Government). Groups A and B inspections may be reinstituted; however, final acceptance shall be withheld until the group C reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action shall be furnished to the cognizant inspection activity and the qualifying activity.

4.5.2 Packaging Inspection. The sampling and inspection of the preservation-packaging; packing and container marking shall be in accordance with the requirements of MIL-C-55330.

4.6 Methods of Examination and Tests.

4.6.1 Visual and Mechanical Examination. The connectors and accessories shall be visually and mechanically examined to ensure conformance with this specification and the applicable military standards (see 3.1, 3.3, 3.4, 3.5, 3.24 and 3.25). In-process controls of component parts, unrelated to lot sizes of finished connectors, may be utilized in lieu of examination of these components in the finished connectors to assure conformance of these component parts.

4.6.2 Disengagement. The plug shall be fully mated to a securely mounted receptacle. A gradually increasing axial tension shall be applied to the plug and the force at separation measured (see 3.6).

4.6.3 Thermal Shock. Accessories or unmated connectors shall be tested in accordance with method 107, condition A of MIL-STD-810 except that the temperature extremes shall be as specified in Table D-8 . At the completion of the last cycle, the connectors shall be returned to room temperature for inspection (see 3.7).

TABLE D-8 . Temperature Extremes

Type	Temperature Extremes	Degrees C	Degrees F
A, B	Low	-65 +0 -3	-85 +0 -3
	High	-125 +3 -0	+257 +5 -0
A, B	Low	-65 +0 -3	-85 +0 -5
	High	-175 +3 -0	-347 +5 -0
A, B	Low	-65 +0 -3	-85 +0 -3
	High	+200 +3 -0	+392 +5 -0

4.6.4 Contact Retention. Axial loads in accordance with Table D-9 shall be applied to the contact. The connector shall have the contact in place during the test. The load shall be applied at a rate of approximately 1 pound per second until the specified load has been reached (see 3.8)

4.6.4.1 Connectors (Accessory Tightened). The axial load shall be applied to the mating end of the contact with the connector accessory tightened. The load shall be applied after the slack in the contact has been taken up, and the displacement of the contact shall be measured under load after the load has been applied for a minimum period of 5 seconds.

TABLE D-9 Contact Retention Axial Loads

Contact Mating end size	Minimum axial load (pounds)
16	10
12	15
8	20
4	20
0	25

4.6.5 Dielectric Withstanding Voltage.

4.6.5.1 Dielectric Withstanding Voltage (Sea Level). Wired, mated connectors shall be tested in accordance with method 3001 of MIL-STD-1344 with the following details and exceptions:

a. The magnitude of the test voltage shall be as specified in Table D-10.

b. The test voltage shall be maintained at the specified value for one minute minimum.

4.6.5.2 Dielectric Withstanding Voltage (Altitude). Mated connectors and unmated connector halves with pin contacts shall be tested in accordance with method 3001 of MIL-STD-1344 with the following details:

a. The magnitude of the test voltage shall be as specified in Table D-10.

b. The test voltage shall be maintained at the specified value for one minute minimum.

c. The leads of all test circuits shall be brought out through the walls of the chamber. There shall be no wire splices inside the chamber.

d. Only the engaging faces of connectors shall be subjected to the $70{,}000 {}^{+\ 0}_{-\ 5000}$ feet altitude.

e. The test article shall be exposed to altitude conditions for 20 minutes prior to test.

4.6.5.3 Dielectric Withstanding Voltage (After Humidity). The mated connectors shall show no evidence of breakdown when the voltage indicated for the applicable service rating in Table D-3 is applied between the shell and the contact in accordance with method 3001 of MIL-STD-1344 except the test voltage shall be applied for 5 minutes (see 3.14).

4.6.5.4 Dielectric Withstanding Voltage (Group B Inspection). Mated connector assemblies shall show no evidence of breakdown when the applicable test voltage of TableD10is applied between the shell and the contact in accordance with method 3001 of MIL-STD 1344. The period of application of voltage shall be one minute minimum (see 3.9).

TABLE D-10 Dielectric Withstanding Test Voltages.

Service Rating	Test Voltages Kilovolts (Crest)
10	20
20	40
50	80
100	160
150	240
200	320

4.6.6 Corona (See 3.10). Connectors shall be tested in accordance with ASTMD 1868, (Circuit, Figure 1). The detector used shall have a sensitivity of less than 1.0 picocoulomb before it is loaded with the test specimen. The detector shall have a uniform frequency response up to 500 kiloherz. The following details shall apply:

(a) Magnitude of test voltage - 110% service rating

(b) Nature of potential - dc. AC tests may be used, properly rated.

(c) Duration of application of test voltage - partial discharges shall be measured for 60 minutes after operating voltage is attained. Voltage shall be increased from 0 to operating test voltage at rate of 500 volts per second.

(d) Points of application of test voltage - center conductor to shell.

(e) Examination after test - connectors shall be visibly examined for evidence of breakdown, arcing, or other visible damage.

(f) Partial discharges shall not exceed more than one discharge per minute above 10 pc. Partial discharges greater than 50 pc are unacceptable.

4.6.7 Impulse Voltage (see 3.11). Connectors shall be tested with a basic insulation level surge voltage (BIL) according to the AIEE-EEI-NEMA Standard Basic Insulation Levels, NEMA Publication No. 109, dated January 1941 to the value shown in Table D-11. The BIL shall be in accordance with the following definition:

"Basic impulse insulation levels are reference levels expressed as impulse crest voltage with a standard wave not longer than 1 1/2 x 40 microseconds (1 1/2 microseconds rise and 40 microseconds decay, Figure D2). Apparatus insulation as demonstrated by suitable tests shall have capability equal to, or greater than, the basic insulation level."

The BIL levels upon which the connectors shall be tested are given in Table D-11.

TABLE D-11 Basic Insulation Level Voltages

Voltage Rating KV Crest	Impulse Withstand Voltage (Crest)
12.5	50
15	60
25	100
50	200
75	300
100	400
125	450
150	550
175	600
200	650
250	800

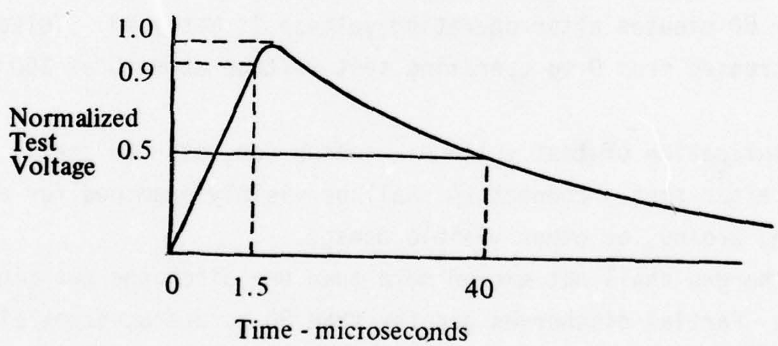


FIGURE D-2 Basic insulation level test voltage profile

4.6.8 Vibration. Complete mated connectors shall be mounted as follows and subjected to the applicable vibration test. Each receptacle shall be mounted on a suitable fixture, which, in turn, shall be attached to a vibration table. A suitable sensor shall monitor the vibration of the receptacle at a point on or near the receptacle. A counterpart plug shall be engaged with the receptacle and tightened to torque requirements. The cables shall be clamped to nonvibrating points at least 8 inches from the rear of the connectors. The clamping length shall be chosen to avoid resonance of the wire cables.

4.6.8.1 Vibration. The mated connector shall be mounted as specified in 4.6.8 and vibrated in accordance with method 2005, test condition II of MIL-STD-1344. The contact shall be wired in series with 100 $\pm$10 milliamperes allowed to flow. A suitable instrument shall be employed to monitor the current flow and to indicate discontinuity of contact or interruption of current flow (see 3.12).

4.6.9 Shock.

4.6.9.1 Shock. Mated connectors shall be subjected to approximately 1/2 sine wave transient shock impulses of 50 gravity units and a duration of 11 $\pm$1 milliseconds. One shock shall be applied in each direction of the three major axes of the connectors. Receptacles shall be mounted on the shock device or carriage. Plugs shall be engaged with the receptacles and held by normal locking means only. A current of 100 $\pm$10 milliamperes shall be allowed to flow.

The wire bundles or cables shall be clamped to structures that move with the connectors. A minimum of 8 inches of wire or cable shall be unsupported behind the rear of each connector. A suitable instrument shall be employed to monitor current flow and to indicate discontinuity of contact or interruption of current flow (see 3.13).

4.6.10 Humidity. Mated connectors shall be exposed to a relative humidity of 95 $\pm$3 percent at a temperature of 71 $\pm 2^{\circ}$C for 14 days. Immediately after exposure, without any forced drying, conduct the dielectric withstanding voltage test of 4.6.5.3.

4.6.11 Contact Resistance. The contact resistance shall be measured in accordance with the contact resistance test of MIL-C-23216 (see 3.15).

4.6.12 Durability. Counterpart solder contact connectors shall be mated and unmated 500 times at a maximum rate of 600 cycles per hour with the coupling rings removed (see 3.16).

4.6.13 Corrosion. Unmated connectors and individual contact samples shall be tested in accordance with method 1001 of MIL-STD-1344. The following details and exceptions shall apply:

a. Test condition letter - B.
b. The samples shall not be mounted but shall be suspended from the top using waxed twine or string, glass rods or glass cord.

4.6.14 Insulation Resistance.

4.6.14.1 Insulation Resistance at Room Temperature. Unmated connectors shall be tested in accordance with method 3003 of MIL-STD-1344. The following details and exceptions shall apply:

a. For lot acceptance testing, where it is undesirable to install actual contacts in connectors, simulated contacts and special techniques may be used in performing this test.
b. The tolerance on the applied voltage shall be ± 10 percent.

4.6.14.2 Insulation Resistance at Room Temperature. Insulation resistance shall be measured in accordance with 4.6.14.1 between the shell and contact. Simulated contacts may be used (see 3.18.1).

4.6.15 Moisture Resistance. Moisture resistance test specimens shall be subjected to the extreme humidity range (see 4.6.15.1) moisture tests, as applicable. The connector shall be mated to the counterpart connector. They shall be mounted horizontally with no drip loops or splices within the chamber. The wires shall leave the chamber through vaportight seals. Prior to the beginning of the test and at the end of the test period and while at the high humidity, the insulation resistance between contacts shall be determined as specified in 4.6.14 (see 3.19).

4.6.15.1 Moisture Resistance, Extreme Humidity Range. Mated solder contact connectors shall be subjected to the following test. The test chamber shall consist of a box approximately 12 inches deep by 16 inches wide by 24 inches long, capable of being sealed, and shall be constructed of materials that, in the presence of water, will not affect deterioration of the samples. A suitable open screen tray shall be provided to support the test specimens approximately 8 inches below the top of the box. Provisions shall be made to bring out wires for measurement purposes through vaportight seals near the top of the box. Suitable controls shall be provided

that will cause the chamber air temperature to vary $5^{o}C$ ($9^{o}F$) once each hour for 20 days, from any temperature between 22^{o} and $28^{o}C$ ($72^{o}F$ and $82^{o}F$), causing heavy condensation to form on the samples once each hour. The bottom of the test chamber shall be covered with approximately 1/4 inch of tap water to start the test. The heat application to supply the temperature variation shall be radiant in nature and applied to the underside of the test chamber.

4.6.16 Contact Engagement and Separation Forces. Socket contacts shall be tested in accordance with the contact engagement and separation force test of MIL-C-23216. Contacts may be tested installed in the connector inserts (see 3.20).

4.6.17 Shell Conductivity. The dc resistance of the wired, mated, assembled connectors shall be measured from a point on the rear accessory thread of the plug to the mounting flange of the receptacle. The point of measurement on the receptacle flange shall be adjacent to the mounting holes on the front or mounting side of the flange. The dc resistance shall not exceed the values specified in 3.21 when measured by the voltmeter-ammeter method. The applied potential shall be 1-1/2 volts dc maximum. A resistance shall be inserted in the circuit to limit the current to 0.100 $\pm$.010 amperes. Probes with spherical ends of 0.5 inch minimum radius shall be used to make the voltage measurements on the connectors. The probes shall not puncture or otherwise damage the connector finish (see 3.21).

4.6.18 Altitude (see 3.30). Mated connectors shall be tested in accordance with method 1004 of MIL-STD-1344. The following details shall apply:

a. The connector cable ends shall be located outside the chamber. The cable ends may be submerged in an insulating liquid or sealed.
b. At the end of the third cycle while the mated connectors are still at altitude the dielectric withstanding voltage test shall be performed as specified in 4.6.5.2.
c. Paragraphs 4.4 and 5(e) of method 1004 shall not apply.

4.6.19 Random Vibration (see 3.31). Wired, mated connectors shall be subjected to method 214 of MIL-STD-202. The following details shall apply:

a. The connector shall be mounted on the table by normal means.
b. Test condition II - Letter J.
c. The duration of test shall be 8 hours in the longitudinal direction and 8 hours in the perpendicular direction.
d. The contacts shall be wired in a series circuit and 100 to 150 milli-amperes shall be caused to flow during vibration.

5. PACKAGING

5.1 Packaging Requirements. The packaging requirements for these connectors shall be in accordance with MIL-C-55330.

6. NOTES

6.1 Intended Use. The connectors covered by this specification are intended for use in high voltage, high power electrical equipment.

6.1.1 Wire Sizes to be Used with Contacts. It is intended that size 12 wire be soldered to at least a size 12 contact; and size 6 wire should be soldered to a size 4 contact because no size 6 contacts are provided and size 4 is the next larger. Satisfactory performance of connectors will be obtained if wire sizes are governed by Table D-1.

6.2 Ordering Data. Procurement documents should specify the following:

a. Title, number, and date of this specification.
b. Style and size of contact.
c. Contact part number with identifying information as to style.
d. Levels of preservation and packaging, and packing required.
e. Reliability level required.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is Wright-Patterson Air Force Base, Ohio and information pertaining to qualification of products may be obtained from that activity.

6.3.1 Pending establishment of adequate and reliable separated contact qualification standards and tests and, in order to insure proper quality and interchangeability, sample connectors will be accepted for qualification testing only from the connector manufacturers who manufactured connectors of this type or style.

NOTICE. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

APPENDIX E

CONVERTERS

HIGH VOLTAGE, HIGH POWER AIRCRAFT CONVERTER
CRITERIA DOCUMENT

1. SCOPE

1.1 Scope - This specification covers the general requirements for devices which convert high power from a 3-phase, alternating-current (ac) generator or a nominal direct-current (dc) aircraft power source to higher voltage power.

1.2 Classification

1.2.1 Family

a. Direct Current to Direct Current: Equipment which converts lower voltage dc power into higher voltage power.

b. Alternating Current to Direct Current: Equipment which converts alternating current power into higher voltage power.

1.2.2 Types

a. Regulated: Equipment which converts power supplying a regulated output voltage and contains provision for parallel operation.

b. Nonregulated: Equipment which converts and supplies power with the voltage regulation dependent on the inherent characteristics of the equipment components.

1.2.3 Classes

a. Class 1: Converters which are liquid-cooled and conform to the altitude-temperature requirements of MIL-E-5400, Class 1, with the maximum ambient temperature of $70^{\circ}C$.

b. Class 2: Converters which are self-cooled and conform to the altitude-temperature requirements of MIL-E-5400, Class 1, except that the maximum ambient temperature shall not exceed $85^{\circ}C$.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

L-P-513	-	Plastic Sheet, Laminated, Thermosetting, Paper-Base, Phenolic Resin.
QQ-S-571	-	Solder, Tin Alloy; Tin-Lead Alloy; and Lead Alloy.
PPP-B-566	-	Boxes, Folding, Paperboard.
PPP-B-601	-	Boxes, Wood, Cleated-Plywood.
PPP-B-621	-	Boxes, Wood, Nailed and Lock-Corner.
PPP-B-636	-	Boxes, Shipping, Fiberboard.
PPP-B-640	-	Boxes, Fiberboard, Corrugated, Triple-Wall.
PPP-B-676	-	Boxes, Setup.
PPP-T-60	-	Tape, Packaging, Waterproof.
PPP-T-76	-	Tape, Pressure-Sensitive Adhesive Paper, (for Carton Sealing).

MILITARY

MIL-I-10	-	Insulating Materials, Electrical, Ceramic, Class L.
MIL-M-14	-	Molding Plastics and Molded Plastic Parts, Thermosetting.
MIL-W-76	-	Wire and Cable, Hookup, Electrical, Insulated.
MIL-P-116	-	Preservation-Packaging, Methods of.
MIL-P-997	-	Plastic Material, Laminated, Thermosetting, Electrical Insulation: Sheets, Glass Cloth, Silicone Resin.
MIL-D-1000	-	Drawings, Engineering and Associated Lists.
MIL-B-5087	-	Bonding, Electrical, and Lightning Protection, for Aerospace Systems.
MIL-E-5400	-	Electronic Equipment, Aircraft, General Specification for

MIL-M-7969 - Motors, Alternating Current, 400 Hz, 115/200-
Volts System, Aircraft, Class A and Class B,
General Specification for.
MIL-F-14256 - Flux, Soldering, Liquid (Rosin Base).
MIL-P-15037 - Plastic Sheet, Laminated, Thermosetting, Class-
Cloth, Melamine-Resin.
MIL-P-15047 - Plastic-Material, Laminated Thermosetting, Sheets,
Nylon Fabric Base, Phenolic-Resin.
MIL-W-16876 - Wire, Electrical, Insulated, High Temperature.
MIL-P-18177 - Plastic Sheet, Laminated, Thermosetting, Glass
Fiber-Base, Epoxy Resin.
MIL-C-45662 - Calibration System Requirements.

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.
MIL-STD-147 - Palletized Unit Loads on 40" x 48" Pallets.
MIL-STD-202 - Test Methods for Electronic and Electrical Component
Parts.
MIL-STD-446 - Environmental Requirements for Electronic Component
Parts
MIL-STD-454 - Standard, General Requirements for Electronic
Equipment.
MIL-STD-461 - Electromagnetic Interference Characteristics
Requirements for Equipment.
MIL-STD-462 - Electromagnetic Interference Characteristics,
Measurement of.
MIL-STD-831 - Test Reports, Preparation of
MIL-STD-810 - Environmental Test Methods.
MIL-STD-1285- Marking of Electrical and Electronic Parts.
MIL-STD-1540- Test Requirements for Space Vehicles.

MS33586 - Metals, Definition of Dissimilar

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

NEMA Publication No. 109	-	AIEE-EEI-NEMA Standard Basic Insulation Level.
ASTM D1868	-	Detection and Measurement of Discharge (Corona) in Evaluation of Insulation Systems.
American National Standard	-	C57.12.00-1973 - General Requirements for Distribution, Power, and Regulating Transformers.
Appendix A	-	High Voltage Cable Criteria Document.
Appendix C	-	High Voltage Capacitor Criteria Document.
Appendix F	-	Aircraft High Voltage Electric Power Characteristics Criteria Document.
AFAPL-TR-76-41	-	High Voltage Design Guide for Airborne Equipment.
MIL-HDBK-251	-	Military Handbook, Reliability/Design Thermal Applications, 19 January 1978.
NATIONAL BUREAU OF STANDARDS Handbook H28	-	Screw-Thread Standards for Federal Services

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.)

AD-A069 473 BOEING AEROSPACE CO SEATTLE WASH F/G 9/5
HIGH VOLTAGE SPECIFICATIONS AND TESTS (AIRBORNE EQUIPMENT). (U)
APR 79 W G DUNBAR, W P KOENIG F33615-77-C-2054
UNCLASSIFIED AFAPL-TR-79-2024 NL

4 OF 6
AD
A069473

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

3. REQUIREMENTS

3.1 Qualification - The converter furnished under this specification shall be a product which has been tested and has passed the qualification tests specified herein, and has been listed on or approved for listing on the applicable Qualified Products List. When there are no products listed or approved for listing on the Qualified Products List, the qualification requirement is waived only by the preparing activity; and procuring activities shall involve first article inspection.

3.2 Specification sheets - The individual equipment requirement shall be specified herein and in accordance with the applicable detail specification sheets. Whenever the requirements of this specification and the detail specification or standard conflict, the requirements of the detail specification or standard shall govern. Any deviation from this specification or from subsidiary specifications or standards, where applicable, must be specifically approved in writing by the procuring activity.

3.2.1 First article - Power converters not covered by specification sheets shall be as specified in an applicable complementary document. These products shall have been tested and passed the inspection in 4.6 and 6.3. This inspection consists of meeting all of the qualification tests of 4.8 through 4.12, inclusive.

3.2.2 Information to be furnished with first article sample - The applicable information outlined in 6.2 shall be furnished with the first article sample, together with any other pertinent information as required by the Government.

3.3 Materials, parts, and processes

3.3.1 Selection of materials, parts, and processes - Materials, parts, and processes shall conform to applicable Government specifications. Materials conforming to contractor's specifications may be used provided the specifications are approved by the Government and contain provisions for adequate tests. The use of contractor's specifications will not constitute waiver of Government inspection.

3.3.1.1 Substitution of materials - If the supplier desires to substitute another material for a specified material or fabricated part, he shall submit a statement to the Government describing the proposed substitution, together with evidence to substantiate his claims that such substitute is suitable. At the discretion of the Government, test samples may be required to prove the suitability of the proposed substitute. Before such substitutions are made, approval for each substitution shall be obtained in writing from the Government.

3.3.1.2 Flammable materials - Insofar as practicable, materials used in the construction of the power converter shall be nonflammable and nonexplosive.

3.3.1.3 Corrosive materials - Corrosive materials used in any of the manufacturing processes shall be removed or neutralized so that no corrosion will result from such use. Insofar as practicable, materials used in the construction of power converters shall be noncorrosive.

3.3.2 Electrical insulating materials - Electrical insulating materials used, including plastics, fabrics, and protective finishes, shall be moisture resistant and shall not support fungus growth. The nonmetals shall not support combustion and shall not be adversely affected by weather, aircraft fluids, temperatures, and ambient conditions encountered during operation of the aircraft. Nonmetals may be treated to conform to this requirement.

3.3.2.1 Laminated phenolic - Laminated phenolic materials shall conform to MIL-P-997, L-P-513, MIL-P-15037, or MIL-P-15047. When electrical characteristics are involved, only natural uncolored materials shall be used.

3.3.2.2 Molded phenolic or melamine - Molded phenolic or melamine materials shall conform to MIL-M-14.

3.3.2.3 Ceramic (external use) - Ceramic materials shall conform to MIL-I-10.

3.3.2.4 Laminated plastic sheet - Laminated plastic sheet, epoxy, shall conform to MIL-P-18177.

3.3.2.5 Materials quality - Molded, ceramic and laminated materials shall be free of flaws such as cracks, delaminations and voids. Sample lots shall be evaluated to assure flaws do not exist in the virgin material or processed materials. Bolting and clamping shall be designed to prevent delamination or cracking of large, thick, laminated and molded parts during installation of parts and wiring.

3.3.3 Metals - The metal materials for each part shall be as specified (see 3.2). When a definite metal is not specified, a metal which will enable the part to meet the requirements of this specification shall be used. Acceptance or approval of a constituent material shall not be construed as a guarantee of the acceptance of the finished product.

3.3.3.1 Corrosion resistance - Materials shall be of a corrosion-resisting type or suitably processed to resist corrosion. Any corrosion that causes malfunctioning of the equipment, shortening of life, impairment of use, or impairment of ease of replacement of parts shall be cause for rejection.

3.3.3.2 Dissimilar metals - Dissimilar metals, as defined by Standard MS33586, when used in contact with each other, shall be protected against electrolytic corrosion, and shall have a low-impedance path to radio-frequency currents as specified in requirement 16 of MIL-STD-454.

3.3.3.3 Solder and soldering Flux - Solder, when used, shall be in accordance with QQ-S-571. Soldering flux shall be in accordance with MIL-F-14256.

3.3.3.4 Screws, nuts, bolts, and washers - All mounting and terminal screws, nuts, bolts, and washers shall be of corrosion-resistant material or shall be protected against corrosion.

3.3.3.5 Corona protection - All mounting and terminal screws, nuts, bolts, and washers near a high voltage part shall have rounded configuration to eliminate probability of corona. Screw threads shall not exist in parts subjected to high field concentration.

3.3.4 Toxic materials - Materials which are known to produce harmful toxic effects under any conditions, including fire, shall not be incorporated in the design without prior approval of the procuring activity.

3.3.5 Standard parts - Standard parts shall be used wherever they are suitable for the purpose, and shall be identified on the drawings by their standard part number. In the event there is no suitable standard part in effect on the date of invitation for bids, commercial parts may be used provided they conform to this specification and can meet the same parts screening procedure as for standard parts.

3.3.6 Nonstandard parts and materials - A request for the use of nonstandard parts and materials shall be submitted to the procuring activity for approval prior to their use in the design and construction of the equipment.

3.3.7 Interchangeability - All parts having the same manufacturer's part number shall be directly and completely interchangeable with respect to installation and performance. Changes in manufacturer's part numbers shall be governed by the drawing number requirements of MIL-D-1000.

3.3.8 Wire - Internal wiring of a power converter is considered to be all the interconnecting wiring beyond the point where the power enters the converter enclosure and processed power leaves the converter enclosure.

3.3.8.1 Insulated wire - When insulated wires are used in wire terminals, the wire shall be of the types and sizes covered in MIL-W-76, MIL-W-16878 or the H.V. cable criteria document. Government approval shall be required when other types and sizes of insulated wires are used as terminals.

3.3.8.2 Wire support - All wires, cables, and buses shall be supported and arranged so that they will withstand abrasion, flexing, and vibration. Clamping shall be such that it will not damage the insulation.

3.4 Design and construction - The article shall conform to the applicable specifications and standards or to the detailed specifications (see 3.2).

3.4.1 Functional description - The power converter shall provide high voltage power to a selected aircraft load upon demand, without arcing, during ground testing and flight operation. Input power to the power converter shall be either from the aircraft power source or an equivalent ground power unit.

3.4.2 Performance

3.4.2.1 Input voltage - The nominal input voltage to the power converter shall be from an alternating current power source or a magnetohydrodynamic (MHD) direct current power source.

3.4.2.2 Alternating current power source - The input voltage from an alternating current power source shall meet the detailed requirements defined in the High Voltage Electric Power Characteristic Criteria Document, see Figures E1 and E2.

3.4.2.2.1 Power factor - The input power factor shall be no less than 80 percent over the input frequency and voltage range under full load conditions. The reactive power for any load conditions less than full load shall not be more than that measured at full rated output.

3.4.2.2.2 Input current balance - From 25 percent to rated load conditions, the current in each phase shall be within 5 percent of the average value of the currents in all phases.

3.4.2.2.3 Reduced input frequency - Units shall not be damaged and shall supply full load current with the output voltage remaining between ±20 percent nominal rated volts when the input frequency is increased or reduced 20 percent for 15 seconds.

3.4.2.3 MHD power source - The input power from a MHD power source shall be a nominal 5000 volts dc which meets the detailed requirements defined in Figure E3.

3.4.2.4 Input voltage transient - The power converter shall be capable of withstanding, without damage, the input voltage transients from the respective

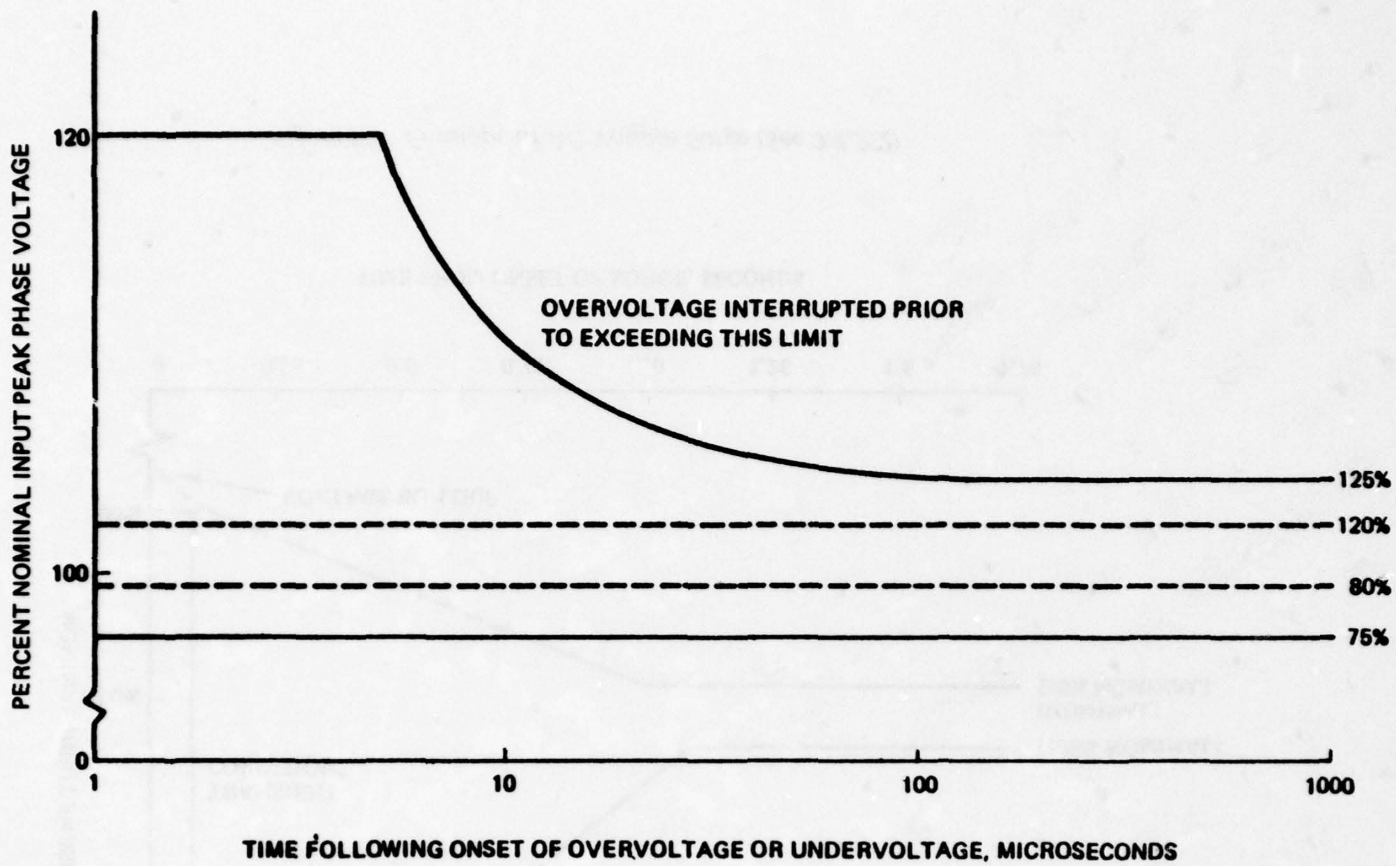


Figure E1: AC Limits for Constant Overvoltage or Undervoltage (See 3.4.2.2)

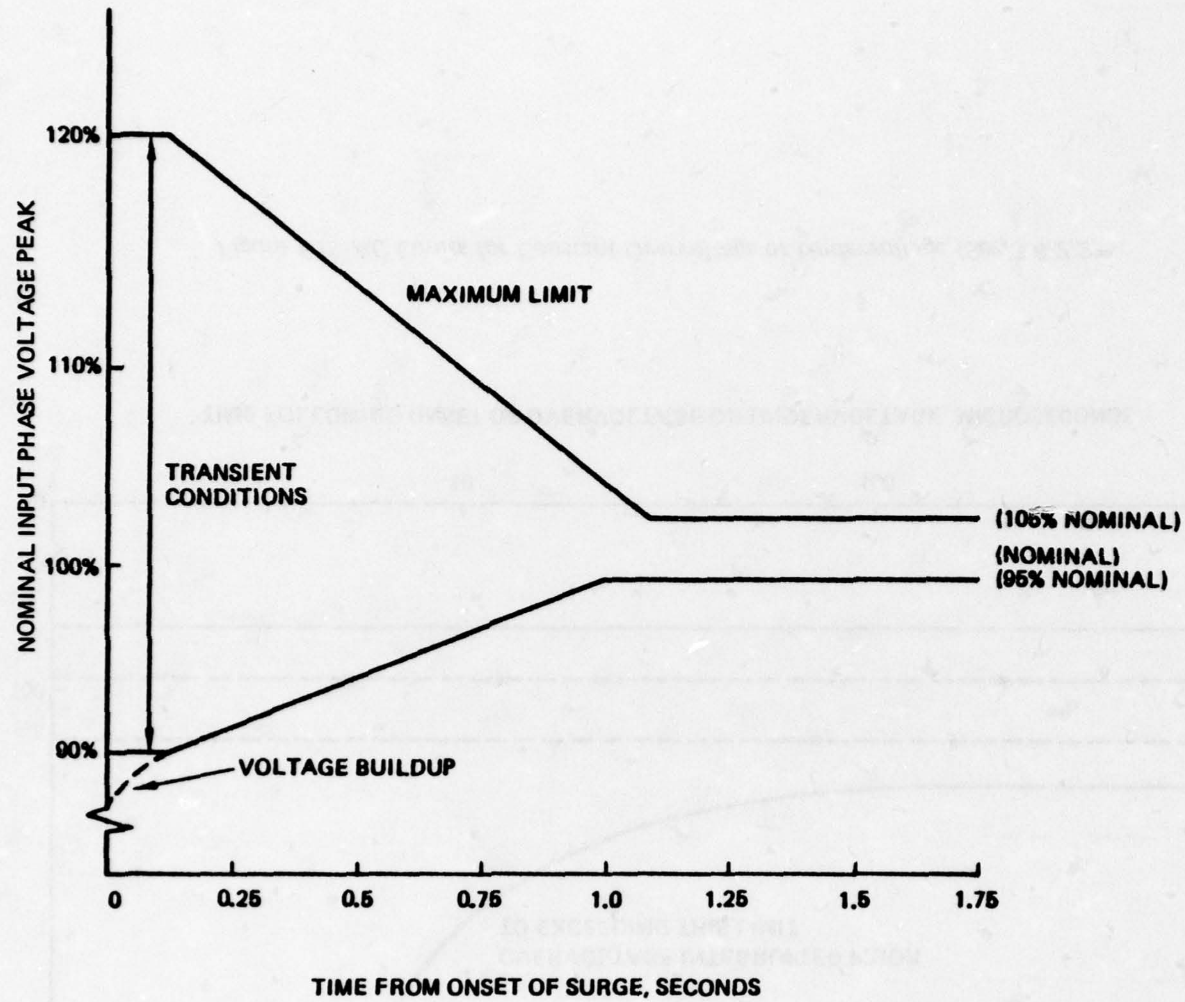


Figure E2: Envelope of AC Voltage Surge (See 3.4.2.2)

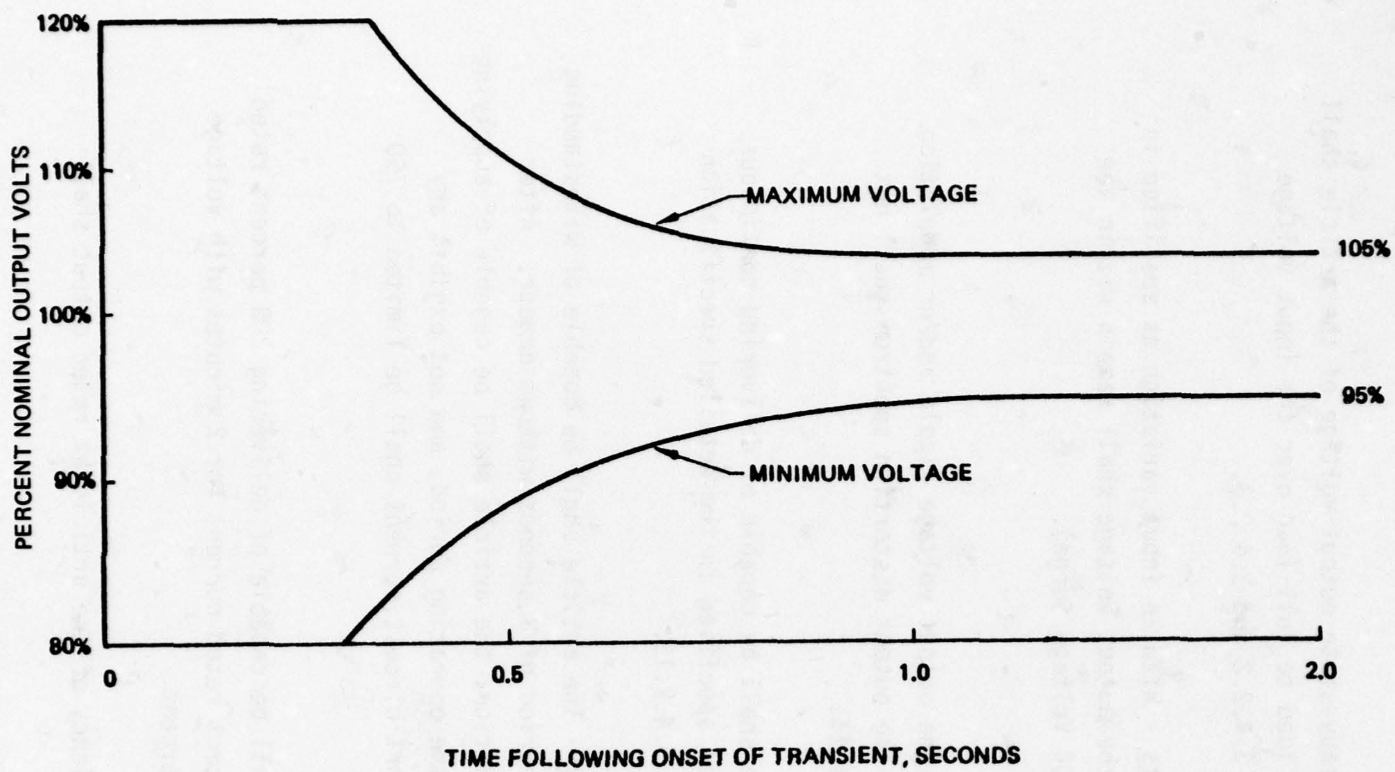


Figure E3: DC Limits for Constant Overvoltage or Undervoltage (See 3.4.2.3)

power source as defined in Figure E2 (Envelope of AC Voltage Surge) and Figure E-4 (Envelope of DC Voltage Surge) for a dc power source.

3.4.2.5 Output voltage - The steady-state output voltage of the article shall not vary more than $\pm 10\%$ from no load to full-load over the input voltage range as specified in paragraphs 3.4.2.2 and 3.4.2.3.

3.4.2.6 Output voltage transients - With an input variation as specified in paragraphs 3.4.2.2 and 3.4.2.3, the output voltage shall remain within the limits of Figure E4 (Envelope of DC Voltage Surge).

3.4.2.7 Ripple and modulation - The output voltage ripple and/or modulation shall not exceed 2 percent rms. The output distortion spectrum shall not exceed the limits shown in Figure E5.

3.4.2.8 Rated load - The article shall be capable of delivering continuous, full-load power, uninterrupted, as specified in the detailed specification sheet, when cooled per paragraph 3.4.2.11.

3.4.2.9 Short circuit capability - The article shall be capable of withstanding a short circuit condition for a period of 3 seconds without damage. After removal of the short circuit condition, the article shall be capable of supplying rated load for the remainder of the operating period, and not exhibit any performance degradation. The short circuit current shall be limited to 750 percent rated current, minimum.

3.4.2.10 Overload - The unit shall be capable of delivering 200 percent rated current for 1 minute and 150 percent rated current for 2 minutes with voltage output variation less than ± 20 percent.

3.4.2.11 Efficiency - The efficiency of the article at rated output shall not be less than:

a. 88 percent for an alternating current source.

b. 85 percent for a direct current source.

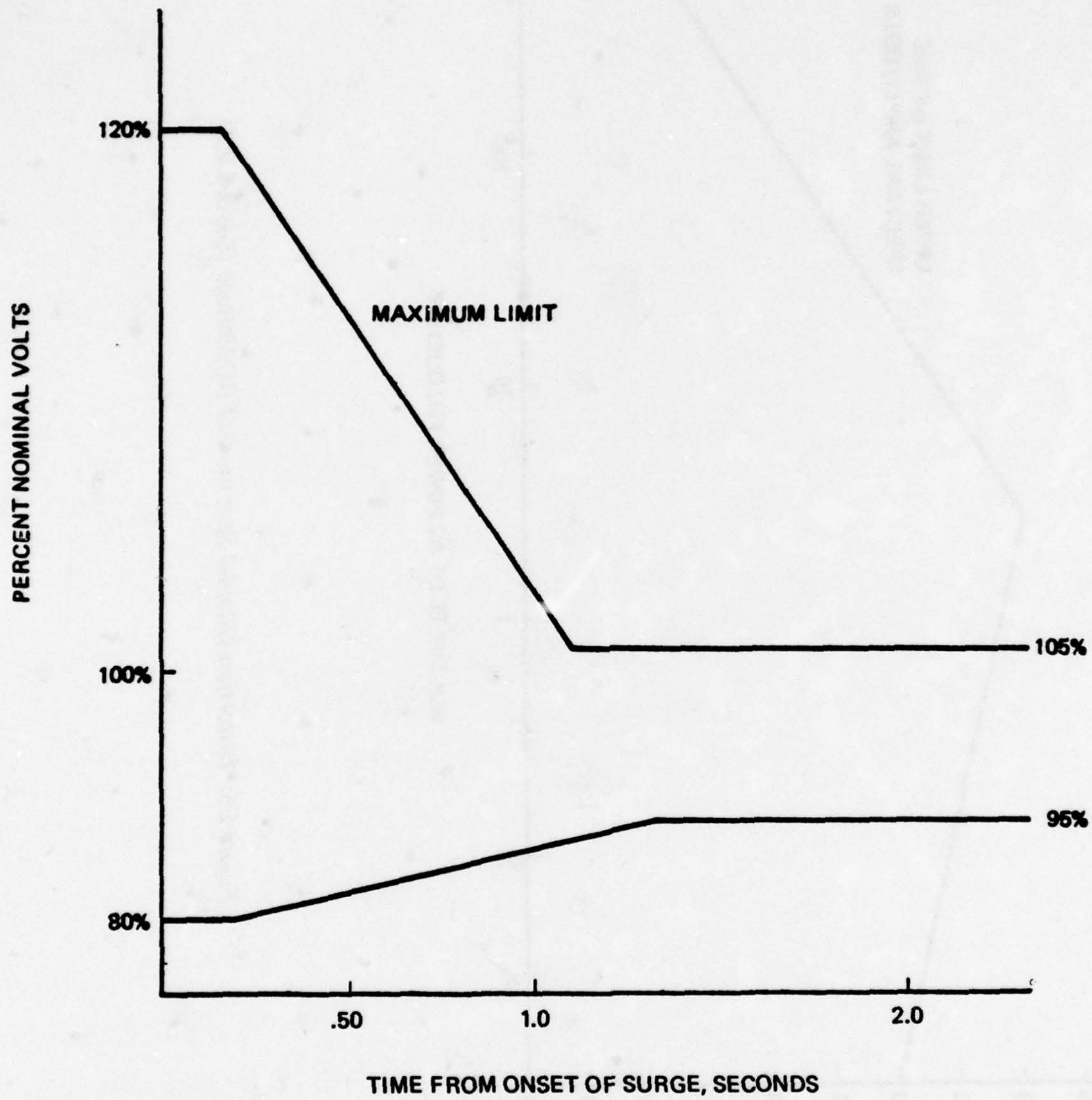


Figure E4: Envelope of DC Voltage Surge (See 3.4.2.4)

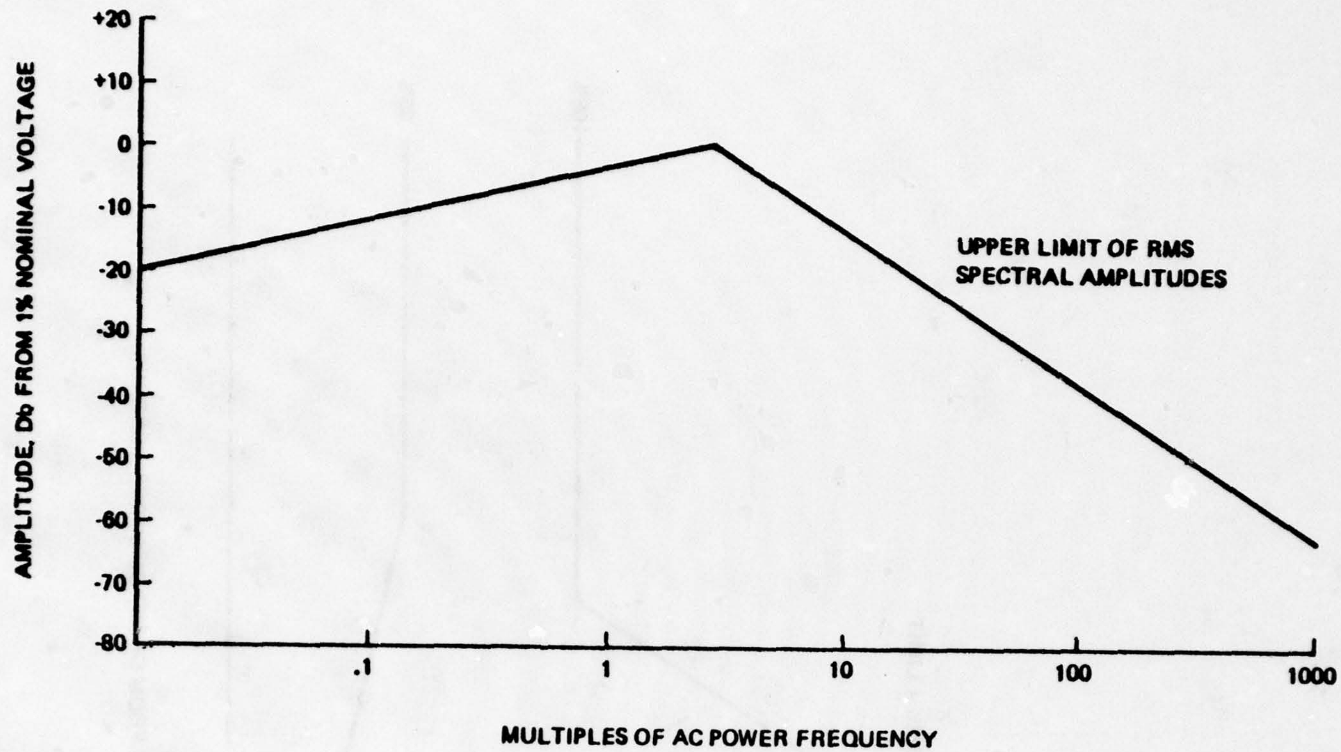


Figure E5: Distortion (Ripple) Spectrum of DC Voltage (See 3.4.2.7)

3.4.2.12 Signal processor - The signal processor shall be shielded with a low radio frequency impedance path to ground and across all mechanical discontinuities. The processor shall operate following impulse spikes generated by partial discharges, momentary short cirtuits, and starting transients within the power converter electrical circuits. All signal processor inputs which are not normally connected externally to the high voltage input or output lines shall be designed with a sufficiently low impedance path to ground to protect the signal processor circuits.

3.4.2.13 Reflected transients - Transient or ripple currents reflected to the input power lines shall be in accordance with the detailed specification.

3.4.2.14 Isolation - The output power lines shall be electrically isolated from the input power lines.

3.4.2.15 Remote sensing - The article shall have provisions for remote voltage sensing. The article shall maintain the voltage regulation requirements of 3.4.2.5 when subjected to voltage drops in the output lines between the article and the remote sense point as specified in the detailed specification.

3.4.3 Operational conditions - The article shall be designed to provide rated output under the following conditions or natural combination thereof, listed in the following subparagraphs.

3.4.3.1 Temperature and altitude - The power converter shall meet the requirements of Paragraph 3.4.2 when subjected to the following ambient temperature range:

a. Operating - The equipment shall be capable of operating at temperatures between -20°C to 55°C at pressure altitudes from 1,000 feet below sea level to 40,000 feet above sea level. It shall be capable of operating for one five-minute cycle in an ambient temperature from -55°C to 71°C at altitudes 1,000 feet below sea level to 40,000 feet above sea level. It shall be capable of withstanding a pressure drop from 15,000 feet altitude to 45,000 feet altitude in 15 seconds while operating.

b. <u>Non-operating</u> - The equipment shall be capable of continuous exposure to ambient temperatures from -55°C to +71°C at pressure altitudes from 1,000 feet below sea level to 40,000 feet above sea level.

c. <u>Cycling</u> - The converter shall be capable of two operating cycles at full load as specified in the detailed specification sheets (3.2).

3.4.3.2 <u>Humidity</u> - The equipment shall be capable of operating at relative humidity ranging up to 100 percent, including conditions where condensation will take place on the equipment as specified in 4.9.3.

3.4.3.3 <u>Sand and dust</u> - The equipment shall be capable of operating under conditions of airborne sand and dust particles as specified in 4.9.4.

3.4.3.4 <u>Salt spray</u> - The equipment shall be capable of operating in an atmosphere containing salt-laden moisture as specified in 4.9.5.

3.4.3.5 <u>Fungus</u> - The equipment shall be capable of operating when exposed to fungi as encountered in tropical areas as specified in 4.9.6.

3.4.3.6 <u>Shock</u> - The article shall be free of leaks, cracks, bursting, or bulging of the cases when tested as specified in 4.9.7.

3.4.3.7 <u>Vibration</u> - When the article is tested as specified in 4.9.8, there shall be no leakage of filling materials and no evidence of other physical damage such as cracks, bursting, or bulging of the case.

3.4.3.8 <u>Flammability</u> - When the article is tested as specified in 4.9.9, there shall be no evidence of violent burning which results in an explosive-type fire, and the coating material used on the article shall be self-extinguishing. The article shall not be considered to have failed, in the event that it is consumed by the applied flame, unless dripping of flaming material or an explosive-type flame has occurred. The article shall be considered to have failed only if an explosion or dripping of flaming material occurs, an explosive-type flame is produced, or if visible burning continues for more than the allowable duration of 3 minutes after removal of the applied flame. Material will be considered self-extinguishing if the following conditions are met:

a. The duration of visible flame does not exceed 3 minutes after removal of the applied flame.

b. There is no explosion, nor any violent burning which results in an explosive-type flame.

c. There is no dripping of flaming material from the converter under test.

3.4.3.9 Nuclear radiation - Exposure limits to nuclear radiation shall be specified in the detailed specification.

3.4.4 Mechanical construction

3.4.4.1 Seal

3.4.4.1.1 Liquid-filled units - When the article is tested as specified in 4.10.2.1, there shall be no evidence of liquid leakage.

3.4.4.1.2 Gas-filled units - When the article is tested as specified in 4.10.2.2, the leak rate shall not exceed 1×10^{-8} standard atmosphere cubic centimeter per second (atm cm^3/s).

3.4.4.1.3 Pressure-vacuum transducer - A pressure-vacuum transducer shall be furnished for sealed-tank and gas-oil-seal construction.

3.4.4.1.4 Liquid temperature transducer - A liquid temperature transducer shall be furnished for sealed tank liquid filled construction.

3.4.4.1.5 Pressure-vacuum bleeder - A pressure-vacuum bleeder device shall be set to operate at the maximum operating pressure (positive and negative) indicated on the nameplate. Effluent gases/liquids shall be ported overboard from the aircraft.

3.4.4.1.6 Tanks - Tanks shall be designed for vacuum filling in the field. A pressure relief device shall be provided on the cover. Maximum operating pressures (positive and negative) for which the converter is to be operated shall be indicated on the nameplate.

3.4.4.2 <u>Cooling</u> - The article external cooling shall be from the aircraft ethylene-glycol-water liquid loop. The article shall receive coolant conditioning from the airplane system, as specified in the detailed specification sheet (see 3.2). Sensors shall be installed within the article to thermally control the article during storage, standby, and operation.

3.4.4.3 <u>Fans, pumps, and control</u> - The equipment for automatic control of fans or pumps for forced-air-cooled or liquid-cooled articles shall be thermally controlled with a manual override switch in parallel with the automatic control. Contacts and sensors shall be enclosed inside the sealed tank. Fan motors shall conform to MIL-M-7969.

3.4.4.4 <u>Lifting, moving, and jacking facilities</u>

3.4.4.4.1 <u>Safety factor</u> - Lifting, moving, and jacking facilities shall be designed to provide a safety factor of 5. This safety factor is the ratio of the ultimate stress of the material used to the working stress. The working stress is the maximum combined stress developed in the lifting facilities by the static load of the component being lifted.

3.4.4.4.2 <u>Lifting facilities</u> - Lifting facilities shall be provided for lifting the cover separately, and also for lifting the internal assembly from the housing using four lifting cables.

Facilities for lifting the complete article (with the cover securely fastened in place) shall be provided. Lifting facilities shall be designed for lifting with four slings at a maximum angle of 30 degrees with respect to the vertical. The bearing surfaces of the lifting facilities shall be free from sharp edges and shall be provided with a hole having a minimum diameter of 13/16 inch (20.6 mm) for guying purposes.

3.4.4.4.3 <u>Moving facilities</u> - The base of the article shall be of heavy plate or shall have members forming a rectangle that will permit rolling in the directions of the centerlines of the segments.

3.4.4.4.4 <u>Jacking facilities</u> - Jacking facilities shall be located near the extreme ends of the junctions of the case.

3.4.4.4.5 Mounting - The points of support shall be so that the unit will withstand the variable orientation of the airplane.

3.4.4.4.6 Mounting studs - When specified (see 3.2), external mounting studs shall be provided with a flat washer and locknut, or with a flat washer, lockwasher, and a nut.

3.4.4.5 Mounting and terminal screws and mounting inserts - Screw threads shall be class 2A or 2B, as applicable (see 3.2), in accordance with Handbook H28. External screw threads, class 2 fit, shall, after receiving a finish, be capable of accepting a nut of class 2B fit and internal screw threads, class 2 fit, shall, after receiving a finish, be capable of accepting a screw of class 2A fit. Maximum installation torque shall be as specified in the detailed specification. Nuts shall run down to within two threads of mounting surfaces.

3.4.4.6 Screw terminals - When specified (see 3.2), external screw terminals shall be supplied with two nuts, two flat washers, and one lockwasher. For cased units, the height of the terminal assembly shall be the distance from the free end of the screw to the terminal mounting surface. The type of terminal, size of screw thread, and the exposed length of threads ± 0.062 inch shall be as specified (e.g., screw, 0.164-32 UNC x 0.375) (see 3.2).

3.4.4.7 Terminal strength - When the article is tested as specified in 4.10.5, there shall be no evidence of loosening or rupturing of the terminals, or other mechanical damage. Bends shall not be considered as damaged unless surface cracking is evident. Except for flexible leads, there shall be no rotation of the terminals. Rotation of the external portion of the metallic portion of a "hook" type terminal exceeding 10 degrees shall not constitute a failure.

3.4.5 Electrical construction

3.4.5.1 Internal wire leads - Internal wire leads shall be attached to the internal component terminals or case by soldering, welding, brazing, or other method (e.g., lead-sweating or nylon-coated wires) in such a manner as to

provide adequate electrical connection and mechanical strength. Where soft solder is used to provide the electrical connection, wire leads shall be anchored mechanically.

3.4.5.2 Wire bundle ties and clamps - *Wire bundle ties shall have the knots* either burnished or enameled. (See "High Voltage Design Guide for Airborne Equipment", Figure 53).

3.4.5.3 Terminals

3.4.5.3.1 Solder terminals (see 4.10.5.1.2) - Solder terminals may be of any shape and shall be capable of complying with solderability requirements of this specification. The height of the solder terminal shall be considered as the maximum distance from the terminal mounting surface to the highest point, including the additional height obtained if semiflexible terminals are straightened. (It is not intended that the "hook" in the hook-type terminal be straightened from its normal hooked position). The type of terminal and the maximum size of wire which the terminal will accept externally shall be as specified (see 3.2).

3.4.5.3.2 Case as terminal - When the case is used as a terminal, any protective coating applied to the mounting surfaces shall be such as to provide a direct conducting path for an electric current from the case to the surface on which it is mounted.

3.4.5.3.3 Bushings - The insulation level of line bushings shall be equal to or greater than the insulation level of the windings to which they are connected.

3.4.5.3.4 Terminal insulators - Terminal insulators shall be epoxy, glass, or ceramic.

3.4.5.3.5 Connectors - Connectors shall be hermetically sealed, circular threaded, high voltage with solder or brazed contacts.

3.4.5.4 Corona protected bushing insulator - When specified (see 3.2), terminals shall be supplied with a corona suppressor where the terminal and terminal hardware are shielded by an angle of at least 30 degrees by a corona suppressor cavity. Terminal hardware shall consist of two nuts, one flat washer, and one lockwasher, or shall consist of one flat washer, one lockwasher, and one cap screw. The terminal post shall not have external threads below the corona suppressor in the bushing. Terminal post finish shall be 100 microns or smoother. The height of the terminal assembly shall be the distance from the top of the corona suppressor to the terminal mounting surface. The type of terminal shall be specified (see 3.2).

3.4.5.5 Solderability - When the article is tested as specified in 4.10.7, it shall meet the applicable criteria for terminal evaluation in the test method.

3.4.5.6 Resistance to soldering heat - When the article is tested as specified in 4.10.8, there shall be no softening of the insulation or loosening of the windings or terminals.

3.4.5.7 Potting, filling, or encapsulating material - The amount and coverage of potting, filling, or encapsulating material used shall be essentially the same for all units of a specific design. Potting, filling, or encapsulating material shall not flow from the case of the article during any of the applicable tests.

3.4.5.8 Grounding - The article shall be grounded by bonding the case(s) to the airplane structure. A common point ground shall be specified for bonding the power source and load in a manner to prevent circulating currents in the ground path, protect the equipment from electromagnetic pulses and lightning, reduce electromagnetic interference, and prevent electrostatic discharges harmful to personnel. A ground path shall provide a path with a current-carrying capacity equal to or greater than that of the input and output conductors.

3.4.5.9 Capacitor - The dielectric strength of the high voltage capacitors shall be as specified in the "High Voltage Capacitor Criteria Document".

3.4.5.10 Surge arrestors - When specified, a surge arrestor ground pod consisting of a tank ground pod, mounted near the high voltage terminals shall be available for surge protection.

3.5 High voltage design and test

3.5.1 Insulation resistance - When measured as specified in 4.11.1, the minimum insulation resistance shall be greater than the value specified for the insulation system in the applicable specification.

3.5.2 Dielectric withstanding voltage - When tested as specified in 4.11.2, there shall be no evidence of arcing, flashover, breakdown of insulation, or damage.

3.5.3 Partial discharges (when specified, see 3.2) - When tested as outlined in 4.8.13 or as specified (see 3.2), the partial discharge maximum magnitudes shall not exceed 100 picocoulombs (peak) at rated voltage.

3.5.4 Impulse - When tested as outlined in 4.11.4 or as specified (see 3.2), impulse voltages shall consist of and be applied in the following manner:

one reduced full-wave
two chopped waves
one full wave

Impulse tests shall be made without excitation.

3.5.4.1 Terminals not being tested - Inputs to low voltage instrumentation and control equipment shall be grounded during impulse tests.

3.5.5 Electromagnetic compatibility - The unit shall be designed to minimize the generation of electromagnetic interference. Enclosed case construction shall provide continuity of electrical shielding with a low radio frequency impedance path to ground and across all mechanical discontinuities. Conducted

and radiated interference produced outside its physical envelope by the operation of the unit shall not exceed the requirements of Specification MIL-STD-461.

3.6 Life - The unit shall be so designed that when operating under any temperature or altitude condition indicated by the detail standard, the useful life of the unit shall be at least 1750 hours operating full load, in a period of 10 years.

3.7 Marking - Power converters shall be marked with the military part number, manufacturer's part number, manufacturer's code symbol, terminal identification (circuit diagram where space permits) and date code and lot symbols in accordance with method I, MIL-STD-1285. Markings shall remain legible after all tests. Any markings of a classified nature shall not be included.

3.8 Safety wiring and staking - Accidental loosening of screws and screw parts and other connections shall be prevented by safety wiring (0.032 inch minimum outside diameter) where practicable, by staking, or other approved methods.

3.9 Workmanship - All machined surfaces shall have a smooth finish and all details of manufacture, including the preparation of parts and accessories, shall be in accordance with the best practice for high quality electrical equipment. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts, plating, lacquering, riveting, clearance between soldered connections, and ruggedness.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Test equipment and inspection facilities - Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection shall be established and maintained by the inspection facility. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-C-45662.

4.2 Classification of inspection - The inspections specified herein are classified as follows:

a. Materials inspection (see 4.3).
b. Qualification inspection (see 4.5).
c. Quality conformance inspection (see 4.6).

4.3 Materials inspection - Materials inspection shall consist of certification supported by verifying data that the materials listed in table E1 used in fabricating the power converter, are in accordance with the applicable referenced specifications or requirements prior to such fabrication.

TABLE E1. Materials Inspection

MATERIALS	REQUIREMENT PARAGRAPH	APPLICABLE SPECIFICATION
Insulating material:		
Laminated phenolic - - -	3.3.2.1	MIL-P-997, L-P-513, MIL-P-15037, or MIL-P-15047
Molded phenolic or melamine -	3.3.2.2	MIL-M-14
Ceramic (external use) -	3.3.2.3	MIL-I-10
Laminated Plastic Sheet -	3.3.2.4	MIL-P-18177
Wire:		
Insulated wire - - - - -	3.3.8.1	MIL-W-76 or MIL-W-16878
Wire supports	3.3.8.2	High Voltage Cable Assembly Criteria Document B

4.4 Inspection conditions - Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202, MIL-STD-454 and MIL-E-5400.

4.4.1 Test frequency - When an ac power source frequency is specified herein, the frequency used shall be within ±2 percent of the nominal value. The test frequency shall be the geometric mean of the specified frequency range or a lower value selected by the manufacturer.

4.4.2 Test voltage - When the rated input voltages are specified with a tolerance (see 3.2), the test voltage shall be the rated voltage (e.g., 5,000 ± 10 volts shall be tested at 5,000 volts). For dielectric withstanding voltage tests, the peak of the voltage applied shall not exceed by more than 5 percent the peak of the pure sine voltage.

4.5 Qualification inspection - Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on a sample unit produced with equipment and procedures normally used in production.

4.5.1 Sample size - A sample of one unit shall be comprised of a power converter and shall be submitted for inspection.

4.5.2 Inspection routine - The sample unit shall be subjected to the inspections specified in Table E2 in the order shown.

4.5.3 Failure - One or more failures of the specified qualification inspection tests listed in Table E2 shall be cause for refusal to grant qualification approval.

4.5.4 Test reports - Samples shall be accompanied with certified test reports in accordance with MIL-STD-831, including a statement that the samples have been subjected to the tests and comply with this specification. Photographs of oscilloscope of ripple voltage shall be submitted (see 4.8.2.1). Samples shall also be accompanied with two copies of outline and detail assembly drawings thereof and two copies of sample instructions with illustrations and diagrams, if necessary, covering the installation of the converter.

4.5.5 Rejection and retest of qualification and quality conformance units - Units which have been rejected or returned to the manufacturer for any reason during qualification or quality conformance tests may be reworked or have parts replaced to correct defects. Before resubmitting the unit, full particulars concerning the rejection and corrective action taken by the manufacturer must be submitted in writing by the manufacturer to the test activity and to the procuring activity. Tests shall not be resumed until such a report is received. Where qualification tests are conducted under the auspices of the manufacturer, the procuring activity shall be advised upon failure of a qualification sample and of the action taken by the manufacturer with regard to the failure.

4.5.6 Retention of qualification - To retain qualification, the supplier shall meet the requirements of 4.5.2 every 36 months. The qualifying activity shall be notified in advance before action is initiated for

Table E2. Qualification Inspection

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Visual and mechanical examination	3.1, 3.4.4.4 to 3.4.5.3inc, 3.4.5.3.5, 3.4.5.4, 3.4.5.7, 3.7, 3.8 and 3.9	4.7.1
Input voltage	3.4.2.1,3.4.2.2	4.7.1, 4.8.2,
Power Factor	3.4.2.2.1	4.8.2.3
Input current balance	3.4.2.2.2	4.8.2.5
Reduced input frequency	3.4.2.2.3	4.8.2
Input voltage transient	3.4.2.4	4.8.3.1
Output voltage	3.4.2.5	4.8.2
Output voltage transient	3.4.2.6	4.8.3.1
Ripple and modulation	3.4.2.7	4.8.2.1
Rated load	3.4.2.8	4.8.2
Short circuit capability	3.4.2.9	4.8.3.2
Overload	3.4.2.10	4.8.3.3
Efficiency	3.4.2.11	4.8.2.4
Signal processor	3.4.2.12	4.8.4
Reflected transients	3.4.2.13	4.8.5
Isolation	3.4.2.14	4.8.6
Remote Sensing	3.4.2.15	4.8.7
Temperature and altitude	3.4.3.1	4.9.1 & 4.9.2
Humidity	3.4.3.2	4.9.3
Sand and dust	3.4.3.3	4.9.4
Salt spray	3.4.3.4	4.9.5
Fungus	3.4.3.5	4.9.6
Shock	3.4.3.6	4.9.7
Vibration	3.4.3.7	4.9.8
Flammability	3.4.3.8	4.9.9
Nuclear radiation	3.4.3.9	4.9.10
Seals	3.4.4.1	4.10.1
Pressure-vacuum transducer	3.4.4.1.3	4.10.2.1
Liquid temperature transducer	3.4.4.1.4	4.10.2.1
Pressure-vacuum bleeder	3.4.4.1.5	4.10.2.2

(Continued)

Table E2. Qualification Inspection (Continued)

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Tanks	3.4.4.1.6	4.10.3
Cooling	3.4.4.2	4.10.4
Fans, pumps and motor	3.4.4.3	4.10.2.3
Terminals	3.4.5.3	4.10.5
Bushings	3.4.5.3.3	4.10.6
Solderability	3.4.5.5	4.10.7
Resistance to soldering heat	3.4.5.6	4.10.8
Grounding	3.4.5.8	4.10.9
Capacitors	3.4.5.9	4.10.10
Surge arrestors	3.4.5.10	4.10.11
Insulation resistance	3.5.1	4.11.1
Dielectric withstanding voltage	3.5.2	4.11.2
Partial discharges	3.5.3	4.11.3
Impulse	3.5.4	4.11.4
Electromagnetic compatibility	3.5.5	4.11.5
Life	3.6	4.12

retention of qualification. The test samples shall be selected from items produced within a previous 6-months production period. However, if this production period cannot be met, the qualifying activity shall determine which items are to be selected for qualification inspection. The supplier shall also forward at 12-months intervals to the qualifying activity a summary of the results of the tests performed for inspection of product for delivery, groups A and B, indicating as a minimum the number of lots that have passed and the number that failed. The results of tests of all reworked lots shall be identified and accounted for.

4.6 Quality conformance inspection

4.6.1 Inspection of product for delivery - Inspection of the product for delivery shall consist of the inspections and tests specified in Table E3. All deliverable high voltage, high power converters shall be subjected to the inspections specified in Table E3.

4.6.1.1 Inspection lot - Inspection shall be for a completely assembled converter of the same family, type, and class having similar electrical characteristics, manufactured under essentially the same conditions, and having similar construction and materials. (Similar construction and materials shall be construed to include differences that will not affect test results).

4.6.1.2 Rejected lots - If an inspection article is rejected, the supplier may rework it to correct the defects, or screen out the defective components and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such articles shall be separate from new articles and shall be clearly identified as reinspected articles.

4.6.1.3 Disposition of units - Units which have passed inspection may be delivered on the contract or purchase order, if the units are accepted and are still within specified electrical tolerances, and if the terminals of the sample units are clean and smooth.

Table E3. Quality Conformance Inspection

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Visual and mechanical examination	3.1, 3.4.4.1 to 3.4.4.1.5 inc., 3.4.4.2 to 3.4.5.8 inc., 3.4.5.9, 3.7, 3.8 and 3.9	4.7.1.1 and 4.7.1.3
Input voltage	3.4.2.1 or 3.4.2.2	4.8.2
Power factor	3.4.2.2.1	4.8.2.3
Input current balance	3.4.2.2.2	4.8.2.5
Output voltage	3.4.2.5	4.8.2
Ripple and modulation	3.4.2.7	4.8.2.1
Rated load	3.4.2.8	4.8.2
Short circuit capability	3.4.2.9	4.8.3.2
Overload	3.4.2.10	4.8.3.3
Efficiency	3.4.2.11	4.8.2.4
Seals	3.4.4.1	4.10.1
Pressure vacuum bleeder	3.4.4.1.5	4.10.2.2
Grounding	3.4.5.8	4.10.9
Surge arrestors	3.4.5.10	4.10.11
Insulation resistance	3.5.1	4.11.1
Dielectric withstanding voltage	3.5.2	4.11.2
Partial discharges	3.5.3	4.11.3
Impulse	3.5.4	4.11.4
Electromagnetic compatibility	3.5.5	4.11.5

4.6.2 Inspection of preparation for delivery - The inspection of the preservation-packaging and interior package marking shall be in accordance with the quality conformance inspection requirements of MIL-P-116. The inspection of the packing and marking for shipment and storage shall be in accordance with the quality assurance provisions of the applicable container specification and the marking requirements of MIL-STD-129.

4.7 Methods of examination and test

4.7.1 Visual and mechanical examination

4.7.1.1 External - The converter shall be examined to verify that the materials, external design and construction, physical dimensions, weight, marking, and workmanship are in accordance with the applicable requirements (see 3.2, 3.4.4.4 to 3.4.5.3 inclusive, 3.7, 3.8, and 3.9).

4.7.1.2 Internal - The internal parts of the converter shall be examined to verify that the materials, internal design and construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.2, 3.4.4.6 to 3.4.5.3 inclusive, 3.4.5.5, 3.4.5.7, 3.7, 3.8, and 3.9). Internal design, construction, and workmanship will include inspection for:

a. Dirt and debris.
b. Loose ends on wire cooling lacing and ties.
c. Rough surfaces on corona shields.
d. Correct spacing of high voltage wiring.
e. Burns, scratches, foreign deposits, and delamination of insulating boards.
f. Grease, oil, or water leaks.

4.7.1.3 Post-test - Converters shall be examined to verify that the protective coating, filling material, and case construction are in accordance with the applicable requirements (see 4.3).

4.8 Electrical performance

4.8.1 Test conditions

4.8.1.1 Altitude and temperature - The steady state output characteristics tests shall be conducted at ambient temperature of $20^{o}C \pm 10^{o}C$ and ambient altitude condition -1000 feet to +5000 feet.

4.8.1.2 Input voltage - Nominal input voltage shall be as specified in the detailed specification.

4.8.1.3 Cooling - The article shall be cooled by passing coolant through the article heat exchanger.

4.8.1.4 Warm up - Prior to each test, unless otherwise specified, the equipment shall be temperature stabilized at $23^{o} \pm 5^{o}C$ for at least 15 minutes.

4.8.1.5 Instrumentation - All instruments used to measure time, voltage, and current shall have an accuracy of 1 percent or less. Instruments shall have been calibrated within 30 days of the date on which the tests described in paragraphs 4.8 are conducted unless the instrument history records provide sufficient evidence to support longer periods between calibration. All meter indications shall be equal to or within the tolerance range specified within this specification.

4.8.1.6 Electrical measurements - Steady state electrical measurements of volts, amperes, ohms, and watts shall be made with laboratory type instruments having an accuracy of 0.75 percent of full scale.

All photographs of oscilloscope traces shall show the sweep time, vertical deflection sensitivity, rise time of the scope, and amplifier, where applicable, and frequency response at the 3 db point.

All oscillograph recordings shall show a calibration trace, and the calculated values of instantaneous voltage, current, and power from the recordings shall be accurate to ± 5 percent. The frequency response of all recording instruments and oscillographs used in the tests shall be included in the test data.

Measurements of frequency shall have an accuracy of ± 1 Hz.

4.8.1.7 Temperature measurements - The accuracy of the temperature measurements shall be $\pm 2^{\circ}C$.

4.8.2 Steady state output characteristics - The ability of the unit to deliver rated load for 5-minutes operation at maximum input voltage for dc power input, or maximum input voltage and minimum input frequency for ac power input, shall be demonstrated. After these runs, the unit shall be loaded at zero, 25%, 50%, and 100% load with nominal input voltage (band frequency). The unit shall be capable of operating for 5 minutes at each load level without exceeding the temperature limits (see 1.2.3). The unit shall be cooled to normal ambient conditions before the start of each test. Measurements shall be taken and recorded of the output voltage, output current, input voltage, input current, input power factor (ac input), coolant temperature, and critical component temperatures which indicate the temperature rise of the converter.

4.8.2.1 Ripple and modulation - During the full load test (100% rated load), the percent modulation V_m shall be measured and recorded; it shall not exceed 2% where:

$$V_m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \times 100$$

V_{max} = maximum voltage, line-to-neutral.

V_{min} = minimum voltage, line-to-neutral.

4.8.2.2 Operating period - The unit shall be capable of two full load operating periods (5 minutes each) with 10 minutes maximum cooling period between operating periods. This shall be demonstrated at the conclusion of the steady state output tests.

4.8.2.3 Input power factor - During the full load test the input power factor shall be measured for a converter with an ac power input.

4.8.2.4 Efficiency - Data for determining the efficiency shall be obtained during the full load and half load tests of 4.8.2.

4.8.2.5 Input current balance - The input current in each phase of the unit shall be measured during the test of 4.8.2 for a converter with an ac power input. The current balance shall be taken at full load, 50% load, and no load.

4.8.3 Transient characteristics

4.8.3.1 Input voltage transient - The input voltage transient defined in 3.4.2.4, Figures E1 and E2, shall be applied to the article power input and control input with the output loaded to rated load. During this test, the output voltage shall be within the voltage limits of Figure E3.

4.8.3.2 Short circuit test - A short circuit of 750 percent rated current sustained for 3 seconds shall be applied to the unit to determine conformance to figure E6. There shall be no damage to the converter. The short

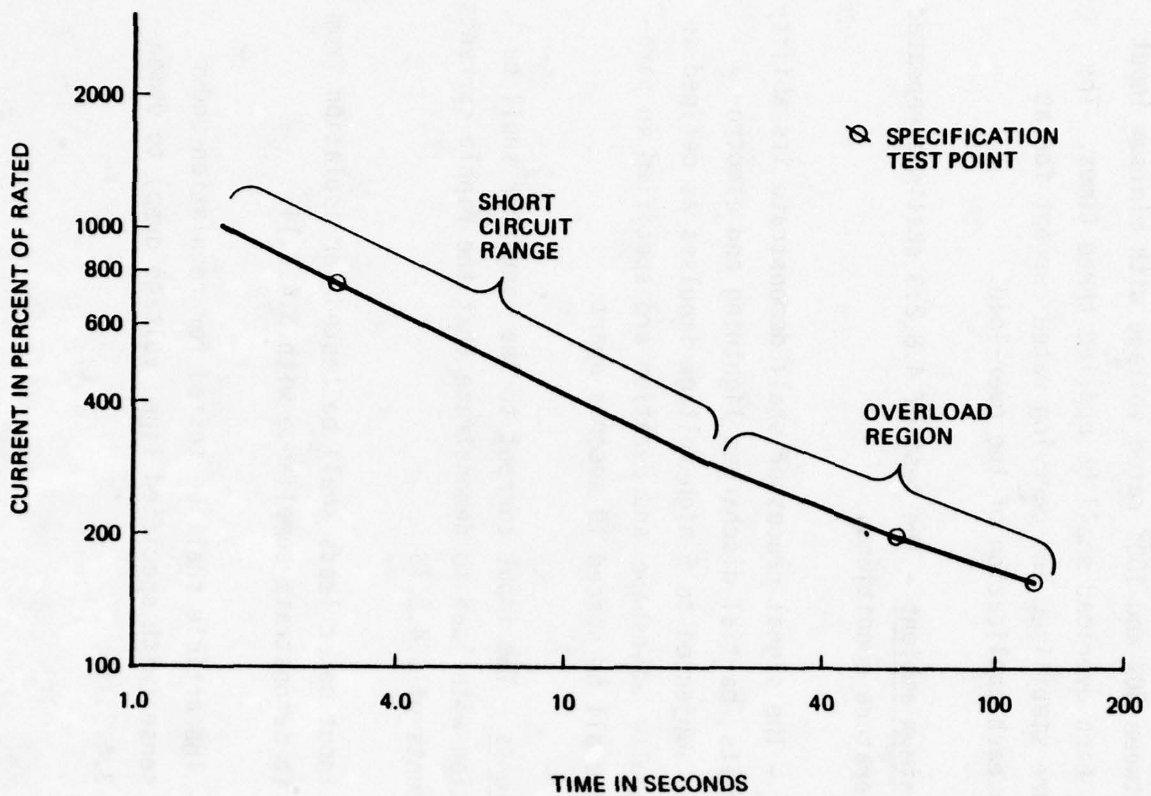


Figure E6: Converter Current Carrying Capacity (See. 4.8.3.2)

circuit shall be applied one time. The unit shall be carrying rated current for at least one minute before application of the short circuit.

4.8.3.3 Overload - The unit shall demonstrate its ability to deliver 150-percent rated current for 2 minutes and 200-percent rated current for 1 minute at an output voltage between 80% and 100% rated voltage with minimum input voltage and frequency. Each overload shall be applied three times. The unit shall be temperature stabilized and carrying rated current for at least 1 minute prior to each application of the over-load.

4.8.3.4 Overload at maximum ambient - The test of 4.8.2.3 shall be repeated at maximum ambient temperature conditions.

4.8.4 Signal processor - The signal processor shall demonstrate its ability to withstand short circuits, partial discharges lightning and electro-magnetic pulses by being subjected to 5 high voltage impulses as defined in paragraph 4.10.9.2. Impulse waveshape and duration are specified in paragraph 4.11.4. Impulses shall be spaced 10 seconds apart.

4.8.5 Reflected transients - The input current to the converter shall be monitored during operation with load to demonstrate that the ripple currents are within the requirements of 3.4.2.13.

4.8.6 Isolation - The input power leads shall be tested for isolation from the output power leads to demonstrate compliance with 3.4.2.14.

4.8.7 Remote sensing - The article shall be tested for regulation under local sense and remote sense (with specified line voltage drop) to demonstrate compliance with 3.4.2.15.

4.9 Environmental tests

4.9.1 Thermal shock (see 3.4.3.1) - The test article shall be tested in accordance with method 107 of MIL-STD-202. The temperature for step 3 shall be the maximum operating temperature for the class. The following details and exceptions shall apply:

a. Test condition - A, 10 cycles, for qualification

b. After cycling - The test article shall be examined for evidence of leakage and other visible damage.

4.9.2 Altitude - Altitude tests are not required for hermetically sealed pressurized subassemblies. Parts such as cables and connectors on sealed or pressurized units, and unpressurized, unsealed units which are designed for operation above 10,000 feet altitude shall be tested in accordance with method 105 of MIL-STD-202. The test articles shall operate at normal voltage at the altitude specified in the detailed specification.

4.9.3 Humidity - The unit shall be subjected to the humidity test, Method 103B, of Specification MIL-STD-202. Immediately following this test the unit shall pass the full load test of 4.8.2 at nominal input conditions and ambient temperature.

4.9.4 Sand and dust - This test is not applicable for hermetically sealed or pressurized subassemblies. Unpressurized or unsealed units shall be tested in accordance with method 110A, of MIL-STD-202. The test articles shall be non-operating during the test.

4.9.5 Salt spray (corrosion). When specified (see 3.2) - The test article shall be tested in accordance with method 101 of MIL-STD-202.

a. Test condition - B.

b. Salt solution concentration - 5 percent.

c. Examination after exposure - The test article shall be thoroughly washed. The temperature shall not exceed $38^{o}C$. The test article shall be placed in an oven maintained at $50^{o} \pm 3^{o}C$ for a period of 24 ± 4 hours. At the end of this period, the test article shall be removed from the oven and examined for corrosion.

4.9.6 Fungus - Unless certification is provided, the test article shall be tested in accordance with method 508 of MIL-STD-810 (see 3.2).

4.9.7 Shock - The test article shall be tested in accordance with 4.9.7.1, or when specified (see 3.2), in accordance with 4.9.7.2.

4.9.7.1 Specified pulse - The test article shall be tested in accordance with method 213 of MIL-STD-202. The following details and exceptions shall apply:

a. Test condition - I, unless otherwise specified.
b. Examinations after shock - The test article shall be examined for evidence of leakage and physical damage.

4.9.7.2 High-impact - The test article shall be tested in accordance with method 207 of MIL-STD-202. The following detail and exception shall apply:

a. Mounting fixtures - Figure "Standard mounting fixtures for electrical controller parts" of method 207.
b. Examinations after shock - As specified in 4.9.7.1(b).

4.9.8 Vibration - The test article shall be tested in accordance with 4.9.8.1 or 4.9.8.2, as applicable.

4.9.8.1 Vibration, low frequency - The test article shall be tested in accordance with method 201 of MIL-STD-202. The following details and exceptions shall apply:

a. Test and measurements prior to vibrating - Not applicable.

b. Method of mounting - The test article shall be rigidly mounted by its normal mounting means.

c. Procedure - When specified (see 3.2) the test article shall be placed in a test chamber and preheated to the specified maximum ambient temperature for the class (see 3.2) plus one-half the allowable temperature rise. Vibration in each plane shall begin 5 minutes after removal from the test chamber.

d. Apparatus - The sequence of vibration shall be as follows: First vertically, and then horizontally in two mutually perpendicular directions. Two machines may be used (one vibrating horizontally and one vibrating vertically), or a single machine may be used which provides for both vertical and horizontal table motion, or a vertical vibrating machine, at the option of the supplier.

e. Examinations after vibration - The test article shall be examined for evidence of leakage and physical damage.

4.9.8.2 Vibration, high frequency (when specified) - The test article shall be tested in accordance with method 204 of MIL-STD-202. The following details and exception shall apply:

a. Mounting of specimens - As specified in 4.9.8.1(b).

b. Test-condition - D, unless otherwise specified.

c. Examinations after vibration - As specified in 4.9.8.1(e).

4.9.9 Flammability (grade 5) - The test article shall be tested in accordance with method 111 of MIL-STD-202. The following details and exception shall apply:

a. Point of impingement of applied flame - One of the lower free corners, so that the flame is just in contact with the test article. The free corners of the test article are those corners which are the greatest distance from the mounting brackets. However, the flame shall be applied so that it will impinge upon the corner or area containing the encapsulating compound.

b. Allowable time for burning of visible flame on specimen - 3 minutes maximum.

c. Examinations during and after test - The test article shall be examined for evidence of violent burning which results in an explosive-type fire, dripping of flaming material, and visible burning which continues beyond the allowable duration after removal of the applied flame.

4.9.10 Nuclear radiation - When specified by the detail specification, a nuclear radiation exposure test shall be conducted in accordance with Standard MIL-STD-446. When required, the unit shall pass the full load test of 4.8.2 after completion of the radiation exposure.

4.10 Mechanical and electrical tests

4.10.1 Seal - The test article shall be tested in accordance with 4.10.1.1, 4.10.1.2, or 4.10.1.3, as applicable. Any unit or subassembly which shows evidence of leakage may be given remedial treatment. After completion of the treatment, the seal test shall be repeated as evidence that such remedial treatment is adequate. All other units in the lot which have been given similar satisfactory remedial treatment shall be acceptable.

4.10.1.1 Liquid-filled units - The test article shall be heated in an oven maintained at a temperature equal to or not more than 5°C greater than the sum of the specified maximum ambient temperature and the allowable temperature rise (see 3.2), for not less than 6 hours.

4.10.1.2 Gas-filled units - The test article shall be tested in accordance with method 112 of MIL-STD-202. The following details shall apply:

a. Test condition - C.

b. Leakage-rate sensitivity - 10^{-6} atm cm^3/s.

c. Procedure IV, as specified (see 3.1 and 6.1.2), test for gross leaks as specified in 4.10.3.

4.10.2 Auxiliary components - Auxiliary components include pressure and temperature transducers, fans, pumps, and controls.

4.10.2.1 Transducers - Pressure-vacuum transducer and liquid temperature transducers shall be tested at least three times during qualification. No damage to the test assembly or sensor shall result from these tests.

4.10.2.2 Pressure vacuum bleeder - The pressure vacuum bleeder valve shall be tested at least three times during qualification. No damage to the test assembly or sensors shall result from these tests.

4.10.2.3 Motors - Fan, pump, and control motors shall be tested for electrical continuity. Fan and pump motors shall function, without failure, during the life test.

4.10.3 Tank design proof pressure - Proof pressure cycle tests shall be conducted in accordance with MIL-STD-1540. The temperature of the test shall be stabilized and maintained at a temperature of 71°C throughout the test.

As an alternative, the test may be conducted at room temperature if the test pressure is suitably adjusted to account for temperature effects on strength and fracture toughness.

Proof pressure cycles shall consist of raising the tank internal pressure to 1.5 times the maximum operating pressure specified in the detailed specification, maintaining this pressure for 5 minutes and then decreasing the pressure to 0 psig. There shall be no evidence of leakage during the test.

The following test cycle shall be performed:

Test	Cycle
Acceptance	1
Qualification	3

At the conclusion of the test there shall be no evidence of yielding of the tank material. The volumetric change shall be determined and recorded. Permanent volumetric change shall not exceed 0.2%.

4.10.3.1 Tank design, burst - Design burst pressure test shall be conducted in accordance with MIL-STD-1540. The temperature of the test shall be stabilized and maintained at a temperature of 71°C throughout the test.

As an alternative, the test may be conducted at room temperature if the pressure is suitably adjusted to account for temperature effects on strength and fracture toughness.

Burst pressure tests shall consist of raising the tank pressure to 4 times the maximum operating pressure specified in the detailed specification and maintaining this pressure to verify that the design burst pressure is met or exceeded. The internal pressure shall be applied at a uniform rate such that stresses are not imposed due to shock loading.

4.10.3.2 Internal vacuum - The tank shall be evacuated to an absolute pressure of 100 pascals, maximum, internal pressure for 15-minutes duration while exposed to ambient pressure externally. No permanent deformation shall be sustained.

4.10.4 Cooling - This test shall be performed during the steady state conformance operating time tests of paragraph 4.8.2.2. The test shall be performed with coolant temperatures and equipment temperatures stabilized at ambient temperature of 55 ± 5°C. During the test, coolant inlet and outlet temperatures shall be recorded for test and standby conditions. Coolant system efficiency shall be determined for each stage of the test. Data on heat rejection (defined as the difference between input and output power expressed in kilowatts) shall be furnished for the above tests. The converter shall conform to the specified requirements of paragraph 3.4.3.1(c).

The coolant system shall be tested in accordance with paragraphs 4.10.3 and 4.10.3.1. Converter hot spot temperatures shall be measured and recorded. There shall be no evidence of leakage during the test.

4.10.5 Terminal strength - The article subassemblies shall be tested as specified in 4.10.5.1 through 4.10.5.2.2, inclusive, as applicable. After each test, the terminals shall be examined for loosening and rupturing and other mechanical damage. Unless otherwise specified, all terminals on each test sample shall be subjected to the following tests, up to a maximum of four identical terminals per sample.

4.10.5.1 Pull

4.10.5.1.1 Solid-wire and insulated wire lead terminals - The test article subassemblies and auxiliary components, such as sensors and motors, shall be tested in accordance with Method 211 of MIL-STD-202. The following details shall apply:

a. Test condition - A.
b. Points of measurement - A force shall be applied in the direction of the axis of termination and shall be increased gradually until the magnitude specified in table E4 is reached and shall be maintained for a period of 5 to 10 seconds.

4.10.5.1.2 Solder terminals - Auxiliary components shall be tested in accordance with method 211 of MIL-STD-202. The following details shall apply:

a. Test condition - A.
b. Points of measurement - A force as specified in table E4 shall be applied to each terminal at the point where the lead from the external circuit connects to it. The force shall be applied in the weakest direction of the terminal and shall be increased gradually to the specified magnitude and shall be maintained at that value for a period of 5 to 10 seconds.

TABLE E4. Pull.

Cross-sectional area of electrode at its smallest point at which lead from external circuit connects	Force
Circular mils	Pounds
$\leq$ 2,000	2.0
> 2,000	5.0

4.10.5.2 Twist or bend

4.10.5.2.1 Solid-wire lead terminals (other than printed circuit terminals) - Following the test specified in 4.10.5.1.1, the article subassembly terminals shall be tested in accordance with Method 211 of MIL-STD-202. The following detail and exception shall apply:

a. Test condition - D.

b. Application of torsion - The body of the component part or the clamped terminal shall be rotated through 360 degrees about the original axis of the bent terminal, in alternating directions, for a total of five rotations, at the rate of approximately 3 seconds per rotation.

4.10.5.2.2 Flat solder terminals - Any terminal that shows permanent deformation greater than 15 degrees of the metal portion of the terminal in the terminal-pull test specified in 4.10.5.1.2 shall be tested in accordance with Method 211 of MIL-STD-202. This test does not apply to terminals which show permanent deformation but are not designed to be bent 45 degrees. The following detail and exception shall apply:

a. Test condition - B.

b. Number of bending operations - Five times through an angle of 90 degrees (45 degrees each side of center).

4.10.6 Bushings - The insulation level of bushings shall be twice rated voltage. Bushings shall be given dielectric withstanding voltages tests and impulse tests.

4.10.7 Solderability - Solder connections for converters shall be tested in accordance with 4.10.7.1 or 4.10.7.2, as applicable. The method in 4.10.7.1 is preferred and shall be specified whenever practicable, otherwise the method in 4.10.7.2 shall be used.

4.10.7.1 Solder bath method - Solder connections shall be tested in accordance with Method 208 of MIL-STD-202. The following details shall apply:

a. Special preparation of specimen - Sample components shall not have been soldered during any of the previous tests.
b. Number of terminations of each part to be tested - A minimum of two of each type of terminal.

4.10.7.2 Soldering iron method - The test shall be performed on solder terminations, attached to converter parts. The solder shall conform to type S, composition Sn60, of QQ-S-571. The flux shall conform to type A or W, as applicable, of MIL-F-14256. The temperature of the bit shall be 300° - $350^{\circ}C$. The iron and solder shall be applied to the termination for 10 seconds. The solder shall be applied for the first 2 seconds. Tinning, as evidenced by the free flowing of the solder with proper wetting of the termination, shall be completed within the first two seconds. The part under test shall remain under standard atmospheric conditions for recovery for fifteen minutes, before final measurements are made.

a. Special preparation of specimen - The surface shall be smooth and properly tinned and the solder terminations shall not have been soldered during any previous test.
b. Number of terminations - in accordance with 4.10.7.1

c. Examinations of terminations - in accordance with Method 208 of MIL-STD-202.

d. Soldering irons - The soldering iron shall have one of the following bit sizes:

(1). 0.3 inch diameter, 1.25 inch exposed length reduced to a wedge shape, over a length of approximately 0.4 inch.

(2). 0.125 inch diameter, 0.5 inch exposed length, reduced to a wedge shape, over a length of approximately 0.2 inch.

e. Point of application of soldering iron -1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal, whichever point is closer to the insulating material.

4.10.8 Resistance to soldering heat - Converter parts shall be tested in accordance with 4.10.8.1 or 4.10.8.2, as applicable. The method in 4.10.8.1 is preferred and specified whenever practical, otherwise the method in 4.10.8.1 shall be used. These tests shall apply to conductors and magnetic devices only.

4.10.8.1 Solder bath method - Converter parts shall be tested in accordance with Method 210 of MIL-STD-202. The following details shall apply:

a. Special preparation of specimen - Sample units shall not have been soldered during any of the previous tests.

b. Depth of immersion in the molten solder - To a point 1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal, whichever point is closer to the insulating material.

c. Test condition - A (350 $\pm 10^{o}$C; immersion, 3 $^{+1/2}_{-o}$ seconds).

d. Examination after test - The parts shall be visually examined and there shall be no seepage of the impregnant, loosening of the terminals, or other mechanical damage. The parts shall be checked for continuity.

4.10.8.2 Soldering iron method - The test shall be performed on all solder terminations, attached to the converter parts. The solder shall conform to type S, composition of Sn60 of QQ-S-571. The flux shall conform to type A or W,as applicable,of MIL-F-14256. The temperature of the bit shall be 300^{o} - $350^{o}C$. The iron and solder shall be applied to the termination for 10 seconds. The solder shall be applied for the first 2 seconds. Tinning, as evidenced by the free flowing of the solder with proper wetting of the termination, shall be completed within the first two seconds. The parts under test shall remain under standard atmospheric conditions for recovery for fifteen minutes, before final measurements are made.

a. Special preparation of specimen - The surface shall be smooth and properly tinned and the solder terminations shall not have been soldered during any previous test.

b. Examinations after test - in accordance with 4.10.8.1.

c. Soldering irons - The soldering iron shall have one of the following bit sizes:

   1. 0.3 inch diameter, 1.25 inch exposed length reduced to a wedge shape, over a length of approximately 0.4 inch.

   2. 0.125 inch diameter, 0.5 inch exposed length reduced to a wedge shape, over a length of approximately 0.2 inch.

d. Point of application of soldering iron - 1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal whichever point is closer to the insulating material.

4.10.9 Grounding and bonding - Resistance measurements shall be conducted on at least two subassembly grounds, representative of the converter. Visual inspection shall be conducted in all converter subassembly and assembly grounds and bonds to the airplane structure. Bonds and grounds between the converter assembly and subassembly parts shall be in accordance with MIL-B-5087.

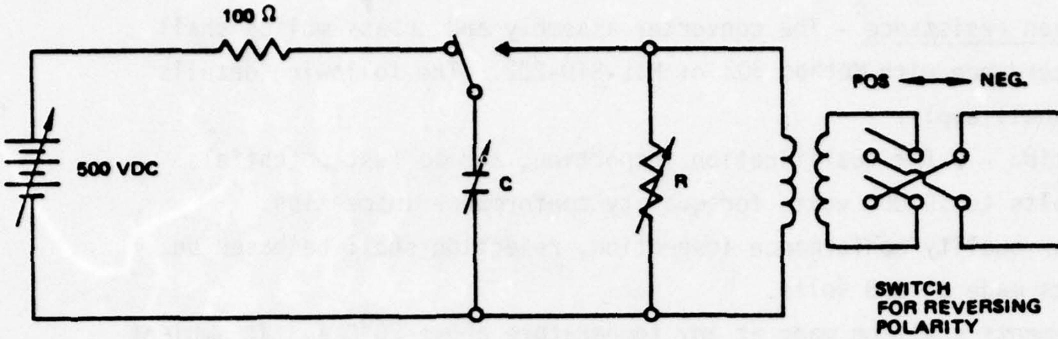
4.10.9.1 Grounding - The bonds selected shall be tested with a direct current source. The measured impedance with average transient current passing through the joint shall be less than 2.5 milliohms, maximum, between the converter assembly or subassembly and the airplane structure.

4.10.9.2 Lightning and electromagnetic pulse susceptibility test - A transient generator similar to that shown in Figure E7 shall be used. The voltage source, capacitor C, and resistor R shall be adjusted to obtain transient "X" in Figure E-7 for ground potential transient susceptibility test, and "Y" for interwire induced transient susceptibility test.

a. Ground potential transient susceptibility test - With the transient generator output connected between ground and all the ground leads of the converter assembly bunched together, and the system operating under full load conditions, ten positive and ten negative ground potential transients (Figure E7, transient X) shall be applied successively. There shall be no failure of components or impairment of subsequent performance as a result of the test.

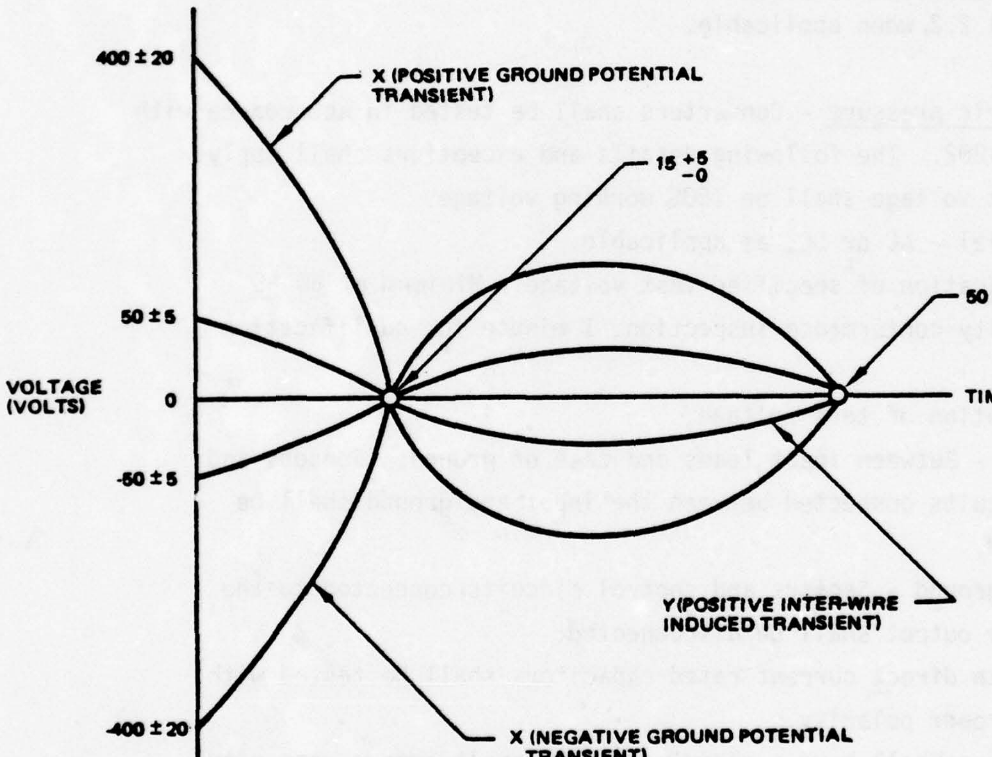
4.10.10 Capacitors - Capacitors shall be tested to determine conformance with 3.4.5.9.

4.10.11 Surge arrestors - Surge arrestors shall be disconnected during impulse testing and dielectric withstanding voltage tests. Surge arrestors shall be tested by applying an impulse 110% greater than the design surge voltage. The surge arrestor shall operate successfully for three consecutive impulses.



TRANSIENT GENERATOR CIRCUIT

(A)



SHAPE OF LIGHTNING TRANSIENT

(B)

Figure E7: Transient Susceptability (See 4.10.9.2)

4.11 H.V. Evaluation tests

4.11.1 Insulation resistance - The converter assembly and subassemblies shall be tested in accordance with Method 302 of MIL-STD-202. The following details and exceptions shall apply:

a. Test condition - B for qualification inspection; and dc test potentials from 500 volts to 10,000 volts for quality conformance inspection. However, for quality conformance inspection, rejection shall be based on measurements made at 500 volts.
b. The measurements shall be made at any temperature above $20^{\circ}C$ and at ambient room humidity, but rejections shall be based on measurements made at $25^{\circ}C \begin{smallmatrix} +10^{\circ} \\ -5^{\circ} \end{smallmatrix} C$ and at a relative humidity not greater than 80 percent.

4.11.2 Dielectric withstanding voltage - Converters shall be tested in accordance with 4.11.2.1 and 4.11.2.2, when applicable.

4.11.2.1 At atmospheric pressure - Converters shall be tested in accordance with method 301 of MIL-STD-202. The following details and exceptions shall apply:

a. Magnitude of test voltage shall be 160% working voltage.
b. Nature of potential - AC or DC, as applicable.
c. Duration of application of specified test voltage - Minimum of 60 ± 5 seconds for quality conformance inspection, 1 minute for qualification inspection.
d. Points of application of test voltage:
    1. Input leads - Between input leads and case or ground. Sensors and control circuits connected between the input and ground shall be disconnected.
    2. Output and ground - Sensors and control circuits connected to the high voltage output shall be disconnected.
    3. Circuits with direct current rated capacitors shall be tested with dc of the proper polarity.
e. High voltage source shall have a minimum of 5 kilovolt-amperes capacity.
f. Examination during and after test - The assembly and subassemblies shall be examined for evidence of arcing, flashover, breakdown of insulation, and damage.

4.11.2.2 Altitude - Converter assemblies and subassemblies designed for operation above 10,000 feet shall be tested as specified in 4.11.2.1 and in accordance with method 105 of MIL-STD-202. The following detail and exceptions shall apply:

a. Test condition or altitude in feet if below 30,000 feet - As specified (see 3.1).

b. Magnitude of test voltage shall be 160% working voltage, AC or DC, as applicable,with polarity in accordance with tested parts.

c. Examination during and after test - Converter assemblies and subassemblies shall be examined for evidence of arcing, flashover, breakdown of insulation, and damage.

4.11.2.3 At reduced voltage - Converter assemblies and subassemblies shall be subjected to the dielectric-withstanding voltage tests specified in 4.11.2.1, except that the test voltages shall be 125% percent of the working voltage and shall be applied for a period of 60 seconds.

4.11.3 Partial discharges - When specified (see 3.2), converters shall be tested in accordance with 4.11.3.1 or 4.11.3.2,or 4.11.3.3, as applicable. The detector used for this test shall have the sensitivity of one picocoulomb or less and shall have a resonably uniform response up to 500 kilohertz. Partial discharge peak magnitudes shall be less than 100 picocoulombs for a 10-minute test at rated voltage.

4.11.3.1 Input circuit - When specified (see 3.2), the converter high voltage input circuit shall be tested for partial discharges. Partial discharge peak magnitudes shall be less than 50 picocoulombs during a 10-minute test at rated input voltage.

4.11.3.2 Output circuit - When specified, (see 3.2), the high voltage output circuit shall be tested for partial discharges. Partial discharge peak magnitudes shall be less than 100 picocoulombs during a 10-minute test at rated output voltage.

4.11.3 Operational - When specified (see 3.2), the partial discharge detector shall be connected to the converter high voltage output circuit and the unit shall be tested for partial discharge. Partial discharge peak magnitudes shall be less than 100 picocoulombs during a 10-minute test with the unit supplying rated voltage. The partial discharge test shall be started 30 seconds after rated voltage is stablized. The output power shall be near zero.

4.11.4 Impulse - When impulse tests on line terminals are specified (see 3.2), they shall consist of and be applied in the following order: one reduced full wave, two chopped-waves, and one full wave in accordance with NEMA Pub. No. 109 and ASTM D1686.

4.11.4.1 Reduced full-wave test - For this test the applied voltage wave shall have a crest value of between 50 and 70 percent of the full wave value given in Tables 4 or 5 of American National Standard C57.12.00-1973 (IEEE Std 462-1973).

4.11.4.2 Chopped-wave test - For this test the applied voltage wave shall be chopped by a suitable air gap. It shall have a crest value and time to flashover in accordance with Tables E4 or E5 of American National Standard C57.12.00-1973 (IEEE Std 462-1973). This gap shall be located as close as possible to the terminals, and the impedance shall be limited to that of the necessary leads to the gap.

4.11.4.3 Connections for impulse tests - In general, the tests shall be applied to each terminal, one at a time.

4.11.4.4 Terminals not being tested - Neutral terminals shall be solidly grounded except in the case of low impedance windings. Line terminals shall be either solidly grounded or else grounded through a resistor with an ohmic value not in excess of the following values:

Nominal System Voltage (kV)	Resistance (Ohms)
345 & below	500
500	400
700	300

4.11.4.5 Wave to be used for impulse tests - A nominal 1.5 x 50 microsecond wave shall be used for impulse tests.

Positive or negative waves may be used for other than front-of-wave tests. The polarity shall be in accordance with the circuit polarity.

The time to crest shall not exceed 2.5 microseconds.

4.11.4.6 Voltage - The basic insulation voltage level to which the convertor shall be tested is 350 percent rated voltage, or as defined in the detailed specification.

4.11.5 Electromagnetic interference - At no load or minimum load point, as applicable, half rated load, and rated load, radiated interference, and both the input and output conducted interference shall be measured using the test procedures and applicable instruments specified in Specification MIL-STD-462 per the requirements set forth in the detailed specification and MIL-STD-461.

4.12 Life - The converter shall be subjected to 120 full load cycles, each cycle of 5 minutes duration. The unit shall be allowed to cool a maximum of 25 minutes between cycles. Room ambient temperature and pressure shall be maintained within the test facility during the test period. The electrical test circuit shall be devised so that an open circuit or short circuit during the 120 life cycles shall be detected and the time of failure recorded. This test may be performed at any ambient temperature provided that the maximum operating temperature for the class is held with $^{+10^\circ}_{-5^\circ}$ C and no drafts or varying air velocities are present. During the last cycle of the life test, output voltage shall be tested to demonstrate compliance with the regulation requirement of 3.4.2.5 and the ripple/modulation requirement of 3.4.2.7.

4.12.1 Post test - Following the last cycle the no-load output voltage shall be tested to demonstrate compliance with the regulation and ripple/modulation requirements.

4.12.2 <u>High voltage evaluation</u> - Upon completion of cycling after a minimum of 10 hours accumulated operating time, the converter shall be tested for insulation resistance (see 4.11.1), and dielectric withstanding voltage (at atmospheric pressure) (see 4.11.2) using 65 percent of initial test voltage. Samples shall also be examined for evidence of physical and electrical damage.

5. PREPARATION FOR DELIVERY

5.1 Preservation-packaging - Preservation-packaging shall be level A or C, as specified.

5.1.1 Level A

5.1.1.1 Cleaning - The converter assemblies and subassemblies shall be cleaned in accordance with MIL-P-116, process C-1.

5.1.1.2 Drying - Transformers and inductors shall be dried in accordance with MIL-P-116.

5.1.1.3 Preservative application - Preservatives shall not be used.

5.1.1.4 Unit packaging - Converter assemblies and subassemblies shall be individually packaged in accordance with the unit packaging requirements of table E5 herein and MIL-P-116,insuring compliance with the general paragraph under methods of preservation (unit protection) and the physical protection requirements paragraph therein.

5.1.1.5 Intermediate packaging - Not required.

5.1.2 Level C - Transformers and inductors shall be clean, dry,and individually packaged in a manner that will afford adequate protection against corrosion, deterioration,and physical damage during shipment from the supply source to the first receiving activity.

5.2 Packing - Packing shall be level A, B,or C, as specified.

5.2.1 Level A - The packaged assemblies and subassemblies shall be packed in accordance with the level A packing requirements of table E5. Boxes conforming to PPP-B-636 shall have all seams, corners,and manufacturer's joint sealed with

tape, two inches minimum width, conforming to PPP-T-60, class 1, or PPP-T-76. The closure, water-proofing, and banding requirements for the other level A shipping containers shown in table E5 shall be in accordance with the applicable box specification. Banding (reinforcement requirements) for all fiberboard containers (PPP-B-636 and PPP-B-640) shall be applied in accordance with the applicable appendix using non-metallic or tape banding only.

5.2.2 Level B - The packaged assemblies and subassemblies shall be packed as specified in 5.2.1, except that the containers shall conform to the level B packing requirements of table XI. Box closure shall be in accordance with the applicable box specification.

5.2.3 Level C - The packaged assemblies and subassemblies shall be packed in shipping containers in a manner that will afford adequate protection against damage during direct shipment from the supply source to the first receiving activity. These packs shall conform to the applicable carrier rules and regulations.

5.2.4 Unitized loads - Unitized loads, commensurate with the level of packing specified in the contract or order, shall be used whenever total quantities for shipment to one destination equal 40 cubic feet or more. Quantities less than 40 cubic feet need not be unitized. Unitized loads shall be uniform in size and quantities to the greatest extent practicable.

5.2.4.1 Level A - Assemblies and subassemblies, packed as specified in 5.2.1, shall be unitized on pallets in conformance with MIL-STD-147, load type I, with a fiberboard cap (storage aid 4) positioned over the load.

5.2.4.2 Level B - Assemblies and subassemblies, packed as specified in 5.2.2, shall be unitized as specified in 5.2.4.1 except that the fiberboards caps shall be class domestic.

5.2.4.3 Level C - Assemblies and subassemblies, packed as specified in 5.2.3, shall be unitized with pallets and caps of the type, size, and kind commonly used for the purpose and shall conform to the applicable carrier rules and regulations.

TABLE E5. Packaging method, unit supplementary and shipping container selection chart.

Unit packaging				Packing		
Net weight of item (pounds)	Grades	Packaging method or submethod of MIL-P-116	Unit or supplementary container	Level A	Level B	Level C
$\leq$2.99		III IA-8 (unless otherwise specified, see 6.1)	PPP-B-566 or PPP-B-676	PPP-B-636, class weather resistant.	PPP-B-636, class domestic.	See 5.2.3
3.00-9.99		III IA-8 (unless otherwise specified, see 6.1)	PPP-B-636, class domestic.	PPP-B-636, class weather resistant.	PPP-B-636, class domestic.	See 5.2.3
10.00-19.99		III	PPP-B-636, class weather resistant.	PPP-B-636, class weather resistant. PPP-B-640, class 2; PPP-B-601, overseas type; or PPP-B-621, class 2.	PPP-B-636, class domestic; PPP-B-640, class 1; PPP-B-601, domestic type or PPP-B-621, class 1.	See 5.2.3
		IA-14 (unless otherwise specified, see 6.1)	Inner container: PPP-B-636, class domestic. Outer container: PPP-B-636, class weather resistant.			
20.00-69.99		III	Unit container shall conform to the designated level of packing and shall serve as the shipping container.			See 5.2.3
		IA-14 (unless otherwise specified, see 6.1)	Inner container: PPP-B-636, class domestic. Outer container shall conform to the designated level of packing and shall serve as the shipping container.			
$\geq$70.00		III	Unit container shall conform to the designated level of packing and shall serve as the shipping container.	PPP-B-601, overseas type or PPP-B-621, class 2. When the weight exceeds 200 pounds, skids shall be applied in accordance with the applicable specification.	PPP-B-601, domestic type or PPP-B-621, class 1. When the weight exceeds 200 pounds, skids shall be applied in accordance with the applicable specification.	See 5.2.3

2.0
1.0

5.3 Marking - In addition to any special marking required by the contract or order, each unit package, supplementary and exterior container and unitized load shall be marked in accordance with MIL-STD-129.

5.4 General

5.4.1 Exterior containers - Exterior containers (see 5.2.1, 5.2.2 and 5.2.3) shall be of a minimum tare and cube consistent with the protection required and shall contain equal quantities of identical stock numbered items to the greatest extent practicable.

5.4.2 Air Force requirements - For Air Force requirements submethods IC-3 and IC-2 with supplementary container conforming to PPP-B-636, class weather resistant, special requirements shall be used in lieu of submethods IA-8 and IA-14, respectively (see table XI).

6. NOTES

6.1 Intended use - This specification covers converters, which are used as devices to convert either alternating current into high voltage direct current or direct current (5kv) into high voltage direct current.

6.2 Ordering data - Procurement documents should specify the following:

a. Title, number, and date of applicable detail specification.
b. MS Part number of the desired converter.
c. Requirements for sampling tests (see 4.4).
d. Level of packaging and packing required (see 5.1).
e. Reinspection date marking required (see 5.3).

6.3 Qualification - With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is Electronics Command; however, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), Dayton, Ohio 45444 (see 3.2).

6.3.1 Submission of drawings - Upon notification of qualification approval, the manufacturer should provide two reproducible copies of outline and detail assembly drawings. Any changes in the reproducible copies from those submitted with the qualification samples should be indicated in detail.

6.3.2 Failure of samples - In case of failure of the sample or samples submitted, consideration will be given to the request of the manufacturer for additional tests only after it has been clearly shown that changes have been made in the product which the activity responsible for the qualification considers sufficient to warrant additional tests.

6.4 Service test - Service tests may be conducted by the procuring activity and will not subject the unit to conditions beyond the requirements of this specification. The tests will be conducted on new units to be provided by the procuring activity.

6.5 Definition - All ac voltages used in this specification should be rms values.

Notice: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that in any way be related thereto.

APPENDIX F

AIRCRAFT HIGH VOLTAGE ELECTRIC POWER CHARACTERISTICS CRITERIA DOCUMENT

AIRCRAFT HIGH VOLTAGE ELECTRIC POWER CHARACTERISTICS CRITERIA DOCUMENT

This criteria document is approved for use by all Departments and Agencies of the Department of Defense.

1. GENERAL

1.1 Scope. This document defines criteria for aircraft high voltage electric power characteristics present at utilization equipment power-input terminals, maintained during operation of the generation, distribution and utilization equipments, and systems applications aspects of utilization equipment.

1.2 Purpose. The purpose of this criteria document is to provide voltage and frequency limits and conditions for aircraft high voltage electric power to be used as criteria for system performance.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on date of invitation for bids, form a part of this document to the extent specified herein.

SPECIFICATIONS

Military

MIL-E-6051	Electromagnetic Compatibility Requirements, Systems

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

STANDARDS

Industry

IEEE STD-100-1972	IEEE Standard Dictionary of Electrical and Electronic Terms

2.1.1 Addresses for documents referenced herein, not obtainable from the Government, are as follows:

IEEE	Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street New York, NY 10017

3. DEFINITIONS

3.1 Definitions of terms not explicitly treated are as given by IEEE Standard Dictionary of Electrical and Electronic Terms.

3.2 AC power characteristics. The designation ac power characteristics relates to alternating voltage and to frequency in single-phase, two-phase, three-phase, and multiple-phase wye-connected neutral or ground return systems. In the event of any conflict between the general requirement of this specification and the detailed specification sheet, the latter shall govern.

3.3 AC voltage. The term ac voltage refers to the gross, root mean square (rms) phase to neutral value unless otherwise designated.

3.3.1 Nominal AC voltage. The nominal ac voltage magnitudes are per Table F1 (See 5.1).

3.4 Crest factor. The crest factor of the ac voltage waveform is defined as the ratio of the peak to rms values.

3.5 DC power characteristics. The designation dc power characteristics applies to voltages in a direct-current, two-wire or ground return system.

3.5.1 Nominal dc voltage. The nominal dc voltage magnitudes are per Table F1 (See 5.1).

3.6 Distortion. AC distortion is the rms value of the ac waveform exclusive of the fundamental. AC distortion includes the components resulting from amplitude modulation as well as harmonic and non-harmonic components. In a dc system, distortion is the rms value of the superimposed alternating voltage.

3.6.1 Distortion factor. The ac distortion factor is the ratio of the ac distortion to the rms value of the fundamental component. The dc distortion factor is the ratio of the dc distortion to the average dc voltage.

3.6.2 Distortion spectrum. The distortion spectrum quantifies ac distortion and dc distortion in terms of the amplitude of each frequency component. The distortion spectrum includes the components resulting from amplitude and frequency modulation as well as harmonic and non-harmonic components of the ac waveform.

3.7 Electrical power characteristics. The electrical power characteristics include values and limits of voltage and frequency parameters, and include related characteristics pertinent to electromagnetic compatibility requirements as well as those designated in ac and dc subcategories. These characteristics are representative of steady and transient states experienced in system operation during all phases of aircraft operation.

3.8 Electric power system. The aircraft high voltage electric power system is that group of connected generation, distribution, protective and conversion equipments active in supplying high voltage electric power to utilization equipments.

3.9 Electromagnetic compatibility. The capability of systems and associated equipment to perform at specified levels in the total electromagnetic environment.

3.10 Frequency. Frequency is equal to the reciprocal of the alternation period of the fundamental of the ac voltage. The unit of frequency is the number of alternations per second of the ac voltage and is designated hertz (Hz.).

3.10.1 Nominal frequency. The nominal frequency is per Table F1.

3.10.2 Frequency drift. Frequency drift is the slow and random variation of the controlled frequency level within steady state limits due to such influences as environmental effects and aging.

3.10.2.1 Frequency drift rate. The frequency drift rate is the time rate of frequency change due to frequency drift.

TABLE F1

NOMINAL VOLTAGE VALUES

DC VOLTAGE		AC VOLTAGE RMS	AC VOLTAGE PEAK	FREQUENCY
	3Ø	1,000/577	1,414/816	400/800/2000 Hz
	3Ø	29,550/17,100	41,790/24,180	400/800/2000 Hz
	2Ø	1,000/707	1,414/1000	400/800/2000 Hz
	2Ø	29,550/20,890	41,790/29,550	400/800/2000 Hz
2-5 kV DC				
5-10 kV DC				
20 kV rectified				
40 kV rectified				
125 kV DC				

3.10.3 Frequency modulation. Frequency modulation is defined as difference between maximum and minimum values of 1/T, where T is the period of one cycle of the fundamental of the phase voltage. When applicable, the rate at which 1/T values repeat cyclically is called the frequency modulation rate.

3.10.4 Frequency transient. The frequency transient is the locus of values defined by the reciprocals of sequential alternation periods of the ac voltage, in instances when the frequency departs from the steady-state value.

3.11 Overvoltage and undervoltage. Overvoltage and undervoltage are those voltages which exceed the combined steady state and surge limits and are usually terminated by the action of protective devices. Although generally short lived, they differ from surges in the sense that, if left unchecked, they would continue indefinitely at their fixed magnitude or until some breakdown in operation was precipitated. Overvoltage and undervoltage can exist indefinitely at values slightly exceeding steady state limits but within the trip limits of the power source protection circuits. They are generally due to loss of regulator control, to unbalance, or to faults, i.e., causes other than those producing surge voltages. On ac systems they apply on all phases or only one phase.

3.12 Ripple amplitude. The ripple amplitude is the maximum value of the difference between the average and the instantaneous values of a pulsating unidirectional wave. (See 2.1, IEEE Standard.)

3.13 Steady state. A steady state condition of the characteristics is one in which the characteristic shows only negligible change throughout an arbitrarily long period of time.

3.14 Utilization equipment. The load equipment is that which receives power from the electric power system. It may be an individual unit, a set of equipments or a complete subsystem receiving power through common equipment terminals or power converters.

3.14.1 Utilization equipment terminals. Utilization equipment terminals through which the electric power system is connected to the utilization equipment are attached to the equipment or are immediately adjacent to the equipment itself. Power interconnections within the utilization equipment are excluded.

3.15 Voltage phase difference. The voltage phase difference is the difference in electrical degrees between the fundamental components of any two phase voltages taken at consecutive zero or dc level crossings of their instantaneous values traced in the negative to positive directions.

3.16 Voltage surge. The voltage surge is defined as a transient departure of the peak values of voltage from the peak instantaneous value of the steady state voltage, persisting for periods in excess of 0.1 microsecond, followed by recovery to within peak values corresponding to steady state. Surges are caused by load changes, and are not expected to activate protective equipment.

3.17 Voltage spike. The spike is a transient of total duration normally less than 0.1 microsecond and is superimposed on the otherwise unaltered instantaneous voltage. Spikes may be characterized here in the time domain in terms of voltage with parameters of duration, risetime and energy. They may also be characterized equivalently in terms of Fourier component amplitudes as a function of frequency. Spikes are not expected to activate protective equipment.

3.18 Voltage unbalance. Voltage unbalance is defined as the maximum difference among phase voltage magnitudes at the utilization equipment terminals.

3.19 Reference ground. The primary aircraft structure is the reference ground for both the ac and dc electrical power systems in metal structure aircraft. In composite structure aircraft, reference ground is additionally designated for specific systems. In some instances, it may be possible to utilize as ground the negative polarity wiring of the dc system, the neutral of the three-phase or multi-phase ac system, or one "side" of a single-phase ac system.

3.20 Power sensitivity. Power sensitivity of utilization equipment is the ratio of incremental output changes to incremental input changes for specified output performance quantities and specified voltage or frequency input-power changes. (See IEEE STD, 2.1)

4. GENERAL REQUIREMENTS

4.1 System equipment compatibility. The characteristics defined in this standard shall be maintained at the utilization equipment terminals during the operation of all expected combinations of power source, distribution, and utilization equipment. System operating modes outside the conditions defined by this standard will be permitted only when specifically authorized.

4.2 Conformance tests. Tests for conformance of the aircraft high voltage electric system to the characteristics stipulated in this document shall be defined as part of the procurement specifications to which this document is applicable, and shall be subject to the approval of the procuring activity.

5. DETAIL REQUIREMENTS

5.1 AC power characteristics. AC power characteristics are those of a single-phase, two-phase, three-phase, or multi-phase wye-connected neutral or ground return system having the nominal voltage and the nominal frequency per Table F1.

5.1.1 Steady state.

5.1.1.1 AC voltage magnitude. The steady state phase-voltage with load shall be within $\pm 5\%$ of nominal voltage.

5.1.1.2 Voltage unbalance. Voltage unbalance applied to the terminals of equipment using a three-phase or multi-phase supply shall be less than 3 percent.

5.1.1.3 Voltage phase difference. The voltage phase difference shall be within $120^{\circ} \pm 2^{\circ}$ for three-phase power and within $90^{\circ} \pm 2^{\circ}$ for two-phase power.

5.1.1.4 Phase sequence. The phase sequence is A-B-C for three-phase power or A-B for two-phase power, corresponding to phase wire markings. See Figure F1.

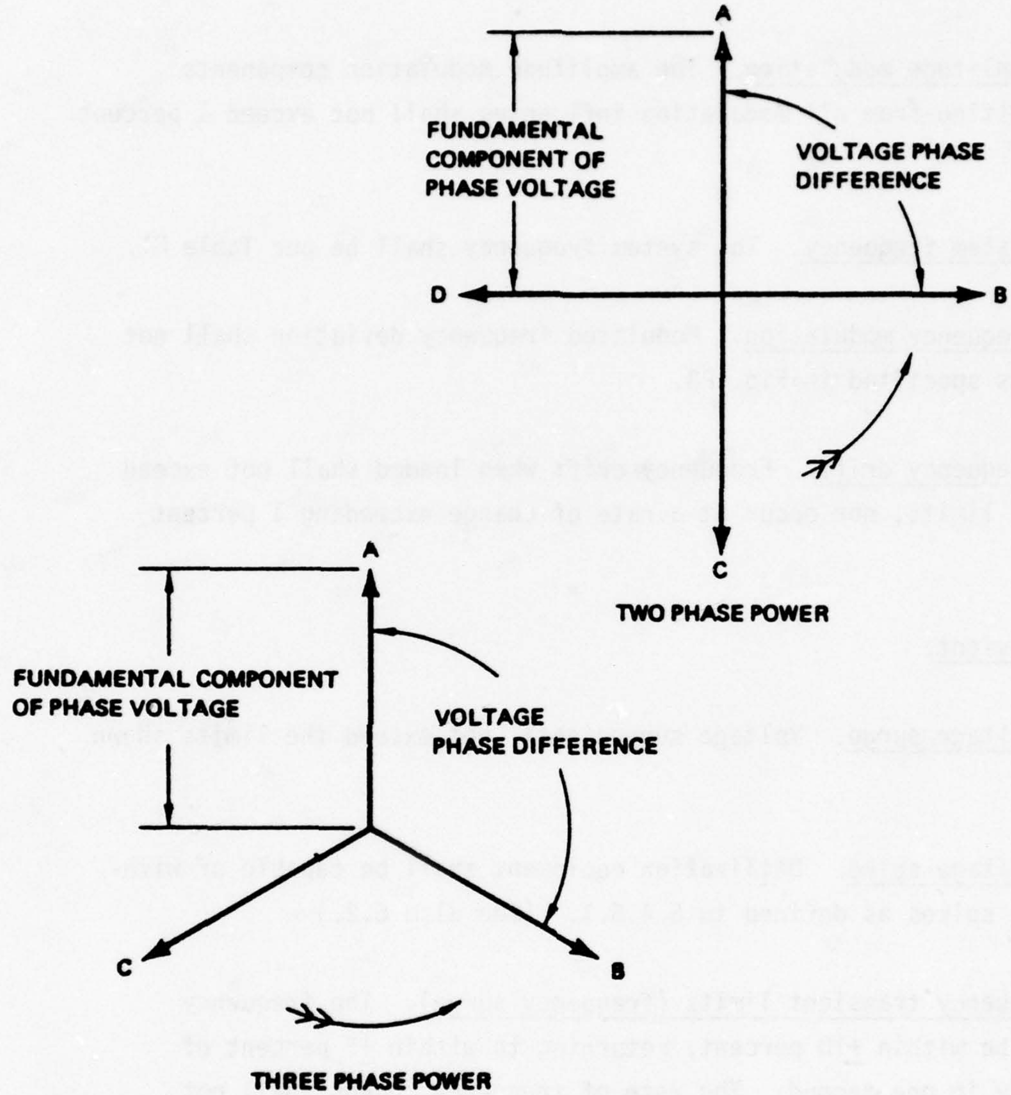


Figure F1: Phasor Diagram Showing Required Phase Sequence Relationship (See 5.1.1.4)

5.1.1.5 AC waveform distortion. The distortion factor for the phase voltage waveform shall not exceed 0.1 nor shall the limits of the ac distortion spectrum exceed the envelope shown in Fig. F2. The crest factor shall not exceed 1.41 ±0.10, nor shall the dc component exceed 0.1 percent.

5.1.1.6 Amplitude modulation. The amplitude modulation components (sidebands) resulting from all modulating influences shall not exceed 1 percent. (See 6.5)

5.1.1.7 System frequency. The system frequency shall be per Table F1.

5.1.1.8 Frequency modulation. Modulated frequency deviation shall not exceed the limits specified in Fig. F3.

5.1.1.9 Frequency drift. Frequency drift when loaded shall not exceed the steady state limits, nor occur at a rate of change exceeding 1 percent per minute.

5.1.2 Transient.

5.1.2.1 Voltage surge. Voltage surges shall not exceed the limits shown in Figure F4.

5.1.2.2 Voltage spike. Utilization equipment shall be capable of withstanding voltage spikes as defined in 5.4.5.1. (See also 6.2.)

5.1.3 Frequency transient limits (frequency surge). The frequency transient shall be within ±10 percent, returning to within ±5 percent of nominal frequency in one second. The rate of frequency change shall not exceed 1000 Hz./second for any period greater than 15 milliseconds.

5.1.4 Overvoltage and undervoltage. The ac overvoltage values shall not exceed the upper limit shown in Figure F5. The ac undervoltage shall not exceed the lower limit of Figure F5.

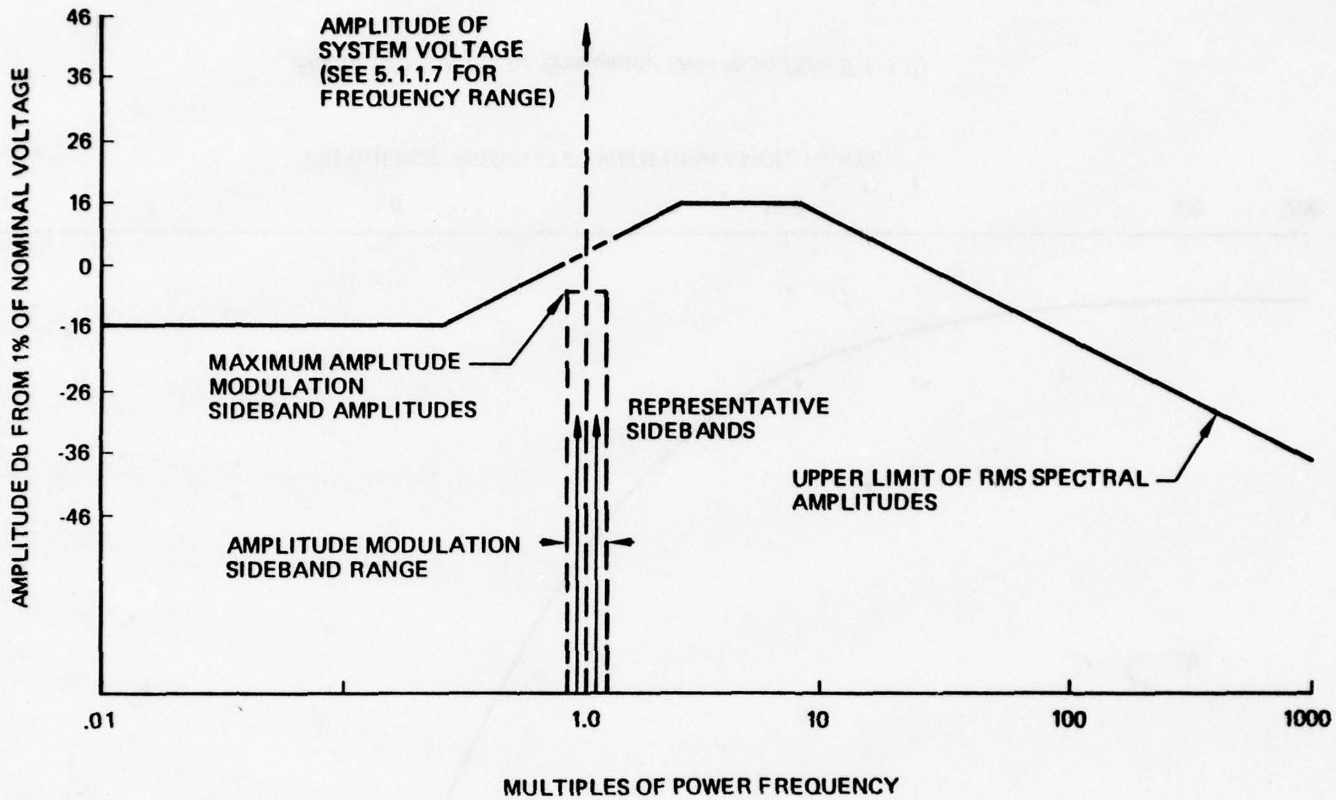


Figure F2: Distortion Spectrum of AC Voltage (See 5.1.1.5)

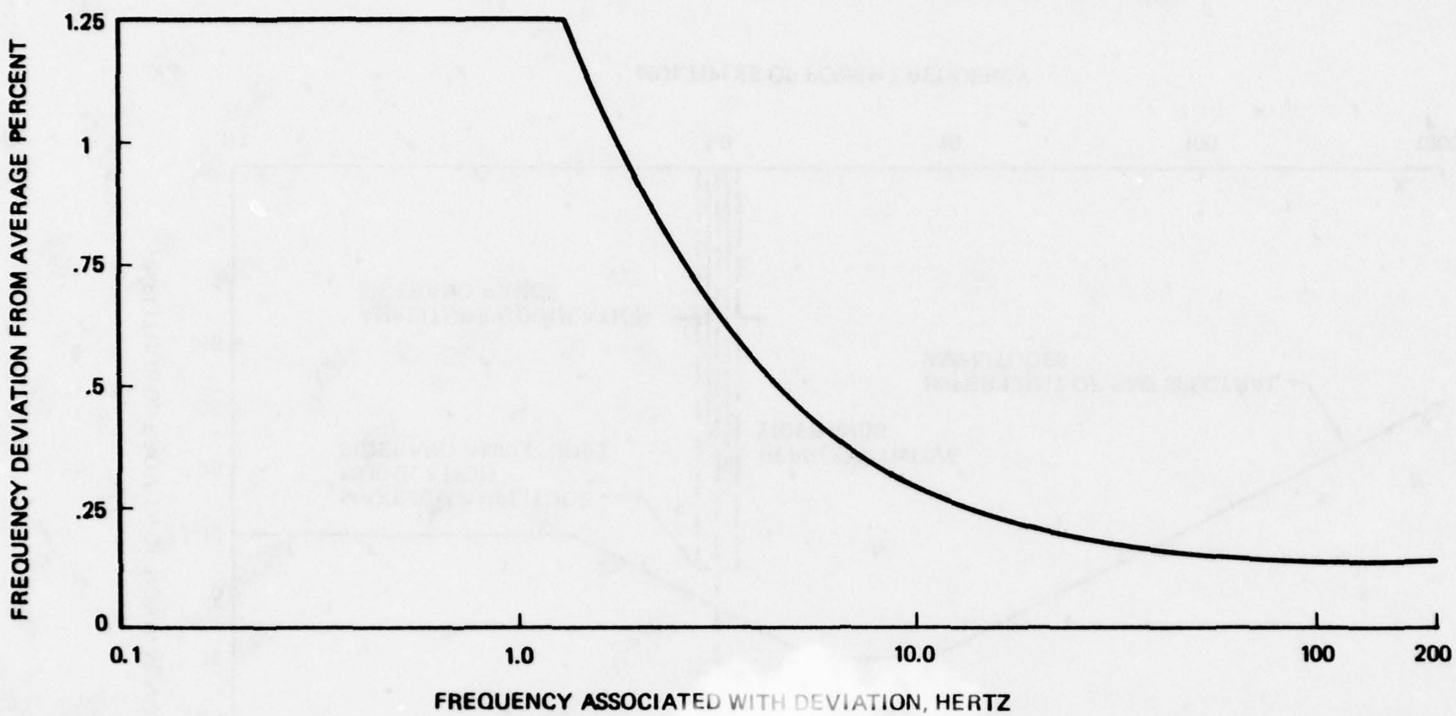


Figure F3: Limits of Frequency Deviation (See 5.1.1.8)

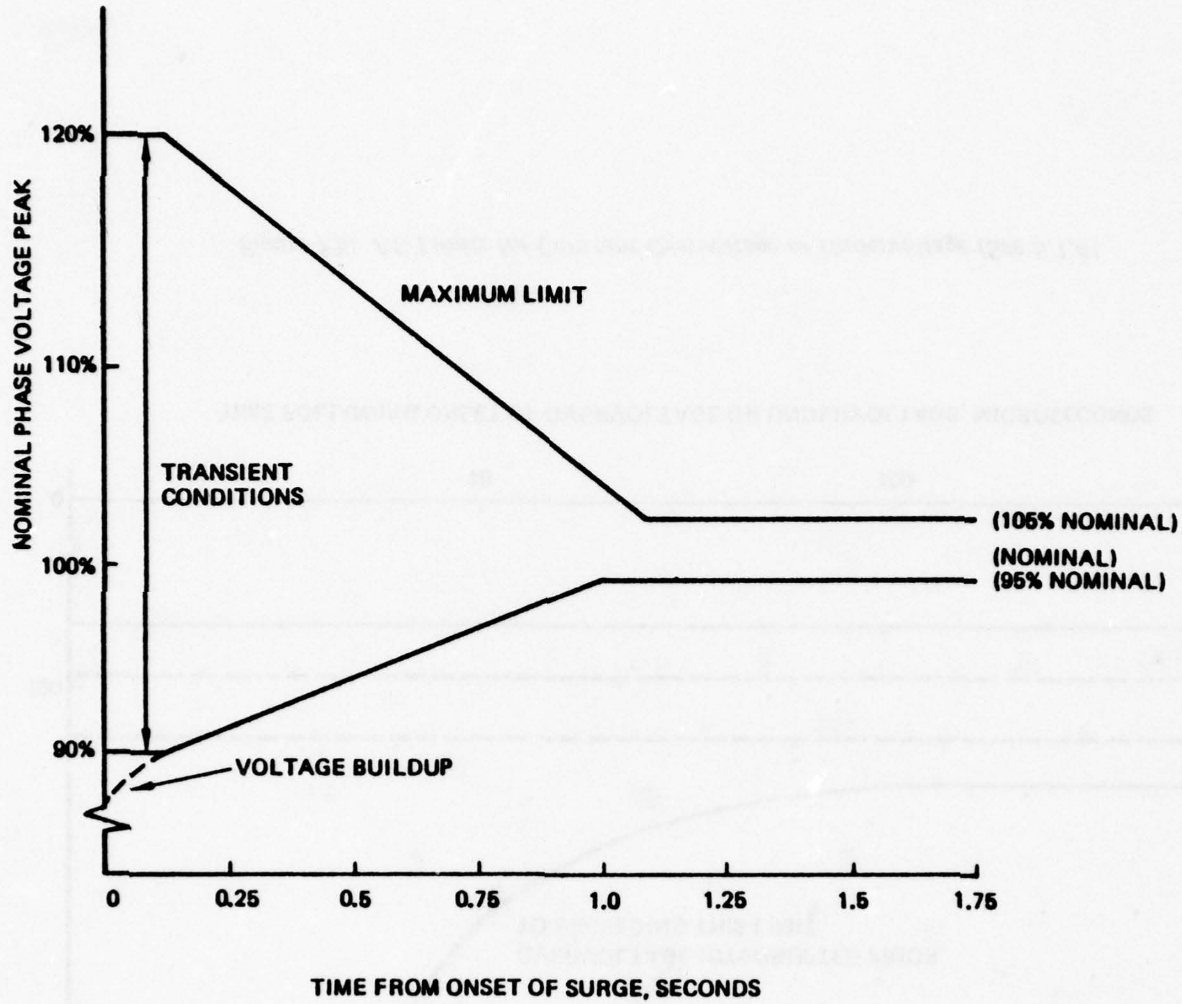


Figure F4: Envelope of AC Voltage Surge (See 5.1.2.1)

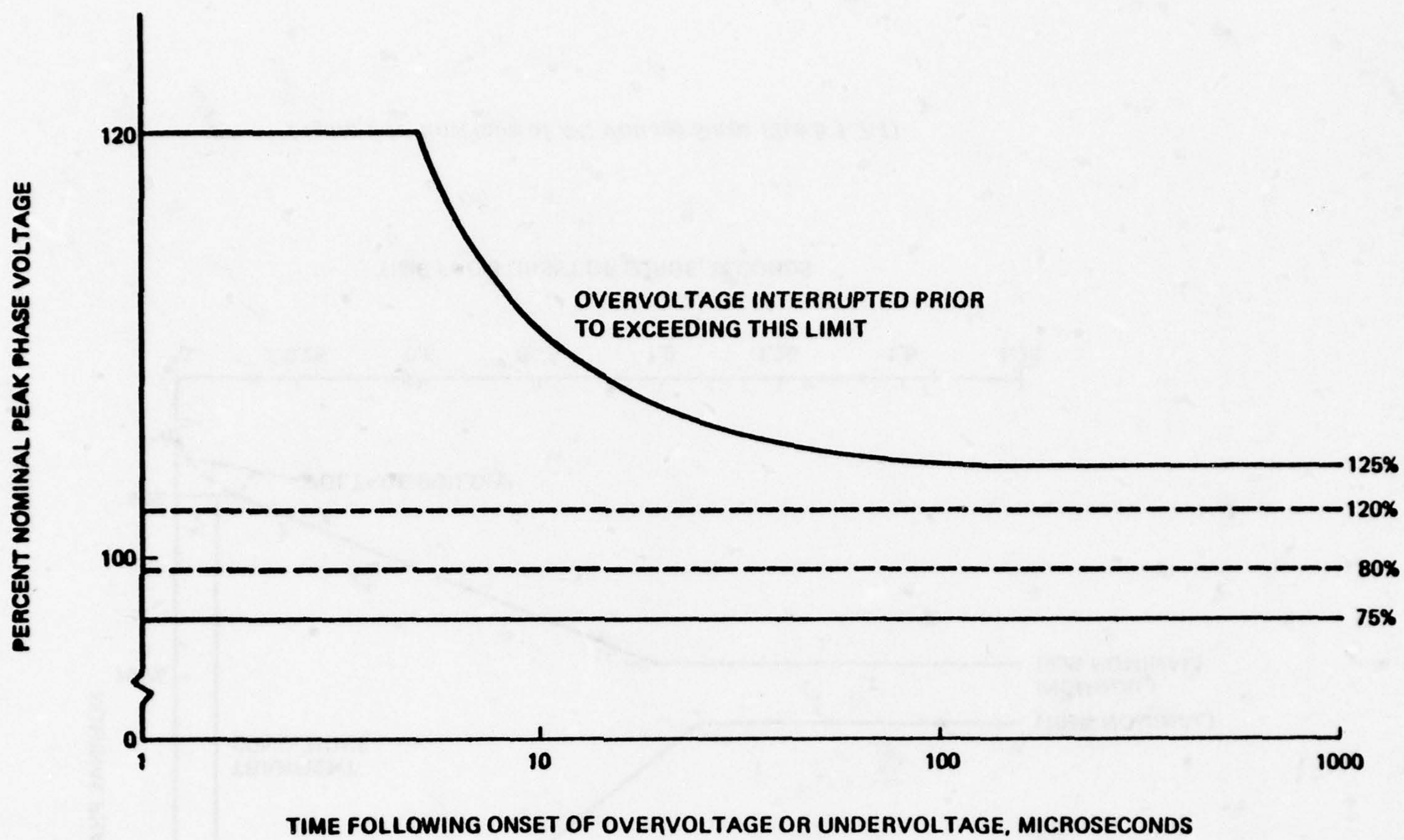


Figure F5: AC Limits for Constant Overvoltage or Undervoltage (See 5.1.4)

5.1.5 <u>Out-of-tolerance frequency (over- and under-frequency)</u>. The limits shall not exceed nominal frequency ±5 percent for more than 5 seconds, or for an interval specifically authorized.

5.2 <u>DC power characteristics</u>. DC power characteristics are those of a direct-current, two-wire or ground return system having a nominal voltage per Table F1.

5.2.1 <u>Steady state. (load requirements)</u>

5.2.1.1 <u>DC voltage magnitude</u>. The dc voltage shall be within ±5% of nominal value.

5.2.1.2 <u>DC distortion</u>. The dc distortion factor shall not exceed 0.02 nor shall the dc distortion spectrum exceed the limits shown in Fig. F6. The ripple amplitude shall not exceed 1 percent (peak).

5.2.2 <u>Transient</u>.

5.2.2.1 <u>Voltage surge</u>. The maximum value of the dc voltage surge shall not exceed the limits shown in Fig. F7.

5.2.2.2 <u>Voltage spike</u>. The requirements of 5.1.2.2 also apply to this paragraph.

5.2.3 <u>Overvoltage and undervoltage</u>. The dc overvoltage values shall not exceed the upper limit shown in Figure F8. The dc undervoltage shall not exceed the upper limit shown in Figure F8.

5.3 <u>Ground support power characteristics</u>. Power supplied by ground support generation systems shall result in power at the utilization equipment terminals at least within the limits specified in 5.1 and 5.2. (See 4.1.)

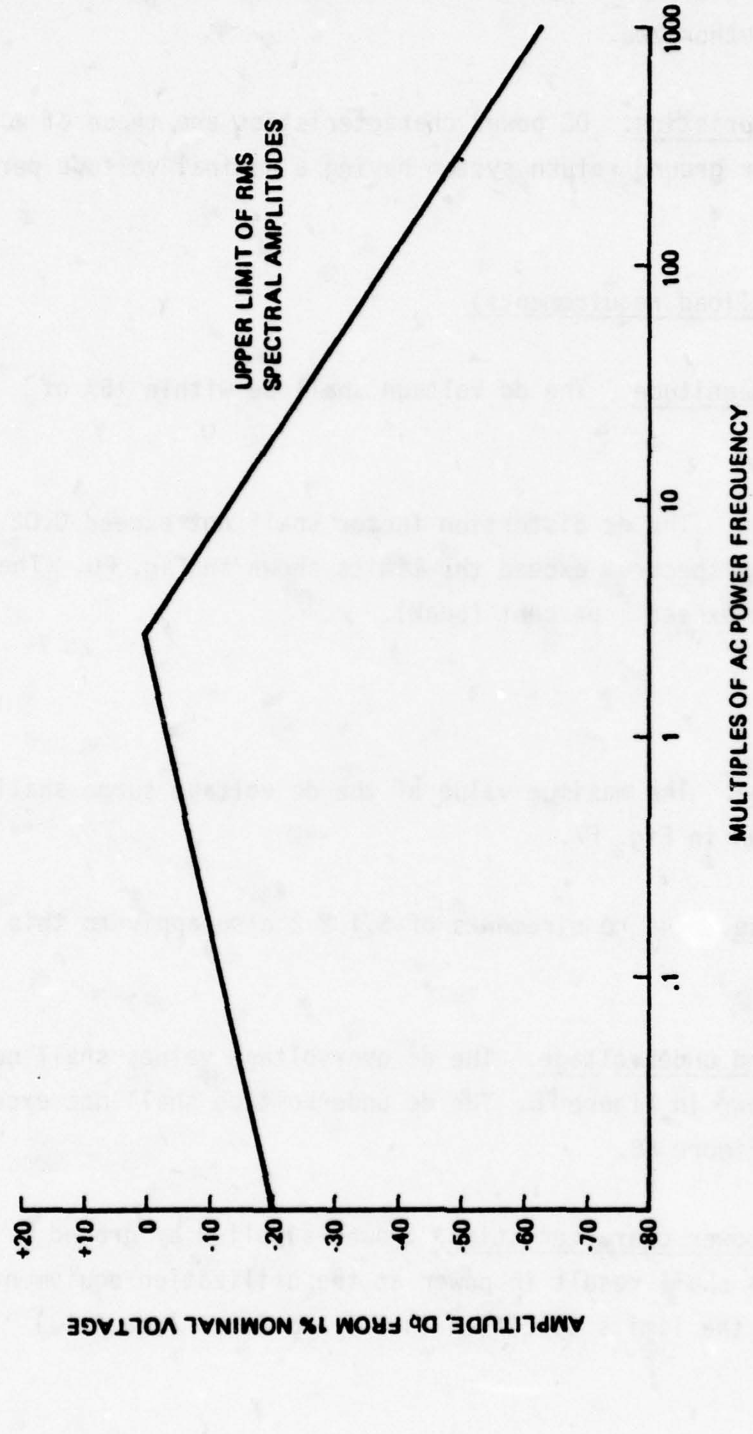


Figure F6: Distortion (Ripple) Spectrum of DC Voltage (See 5.21.2)

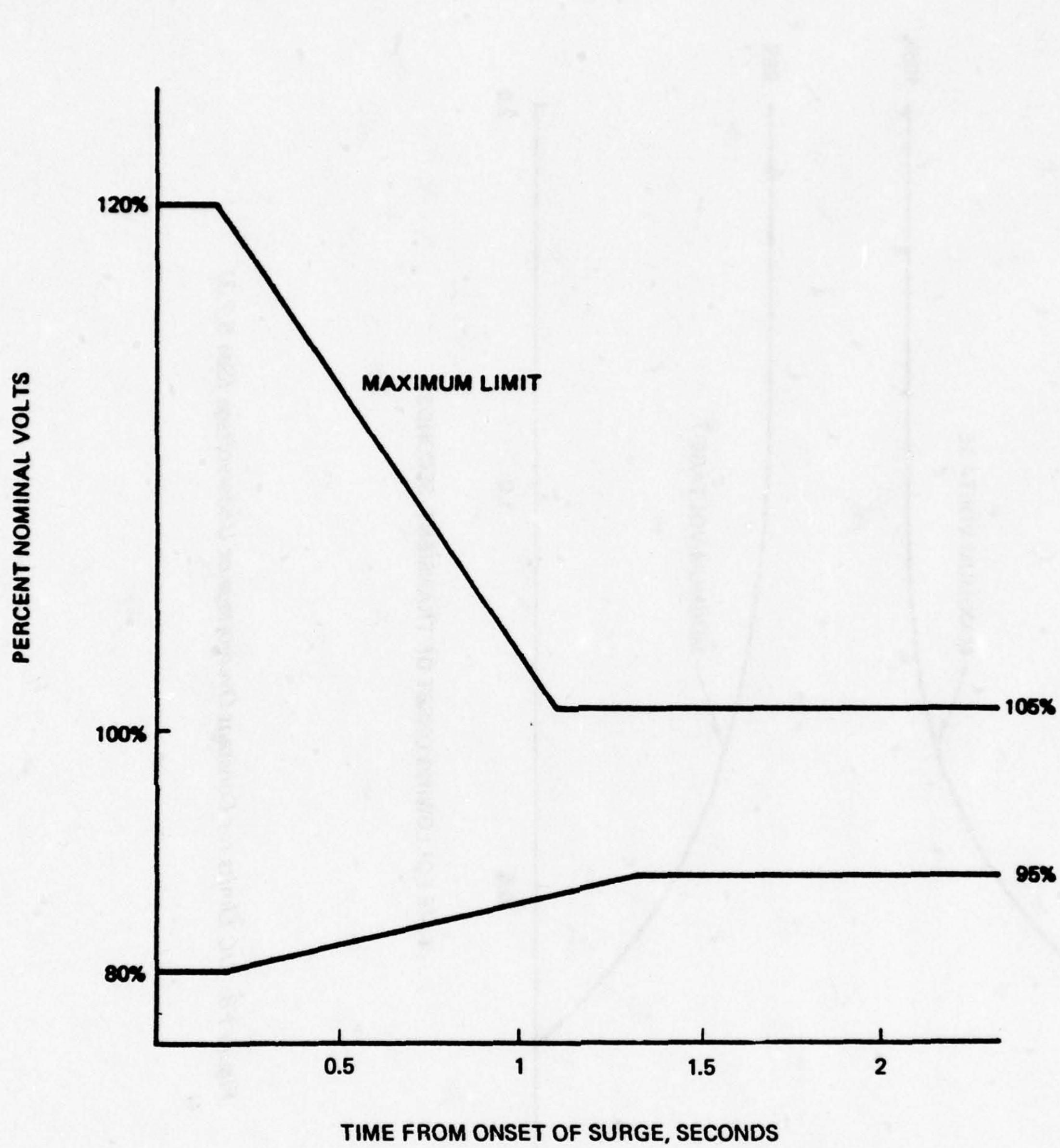


Figure F7: Envelope of DC Voltage Surge (See 5.2.2.1)

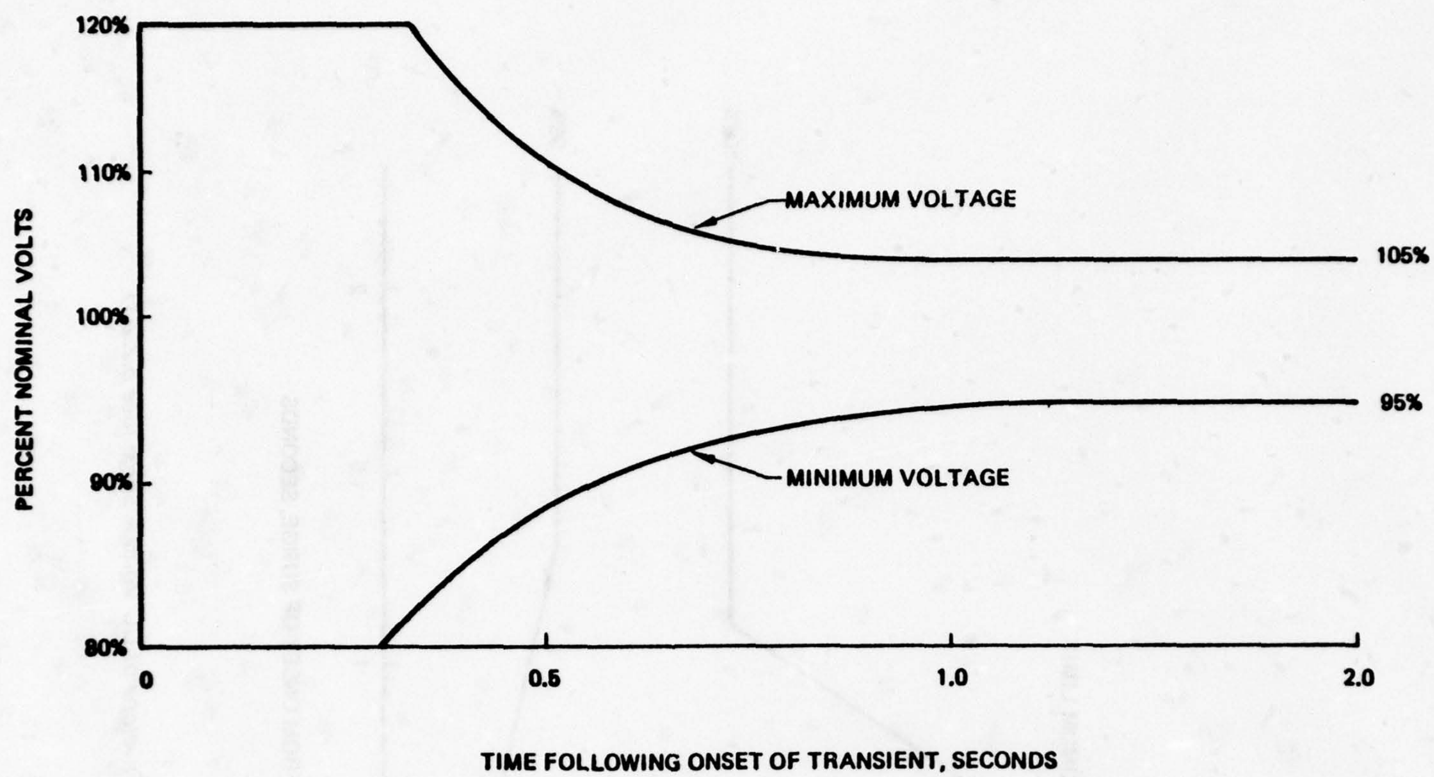


Figure F8: DC Limits for Constant Overvoltage or Undervoltage (See 5.2.3)

5.3.1 AC voltage.

5.3.1.1 AC voltage magnitude. The voltage range at the point of connection to the aircraft shall be per Table F1.

5.4 System operation of utilization equipment.

5.4.1 Power types. Utilization equipment shall operate from one or more of the types of power defined in Table F1, as required by the equipment specifications.

5.4.2 Equipment performance. The utilization equipment shall function as follows:

a. Unless otherwise specified, all performance requirements must be met when the utilization equipment is supplied one or more power types specified in 5.4.1 above, when operated in a system, and when operated within the appropriate limits specified in 5.1 and 5.2, which must be within the limits of the equipment specification.

b. Utilization equipment need not maintain required performance when supplied voltages between the applicable surge limits and the associated overvoltages and undervoltages of 5.1.4 and 5.2.3, and frequencies between applicable steady state limits and the transient limits of 5.1.3, unless otherwise required. (See 3.11)

c. Exposure to the voltages and frequencies stipulated above in this paragraph 5.4.2 shall not result in an unsafe condition, nor impair the ability of utilization equipment to maintain performance requirements in subsequent operation. After such exposure the utilization equipment shall be automatically restored to specified operating performance unless otherwise required.

5.4.3 Precision power. The electric power system shall not be used directly as a source of reference voltages or frequencies, or timing signals unless specifically authorized by the procuring activity.

5.4.4 Partial power failure. The failure of one or more phases of a polyphase equipment, or the loss of power to any or all pairs of power-input terminals of equipments which require both ac and dc power, shall not result in an unsafe condition.

5.4.5 Power sensitivity tests. Tests for utilization equipment sensitivity to the appropriate power conditions shall be as defined in the system procurement specification. Detail equipment tests will not be invoked unless specifically called out. (See 6.3.)

5.4.5.1 Voltage spike. Subsequent to the application of a spike waveform to the power-input terminals of utilization equipment functioning according to corresponding detail specification, this equipment shall meet 5.4.2. The spike waveform, produced by a power source with an impedance of 50 ±5 ohms, shall satisfy the following requirements:

Open-circuit voltage: 2.5 x nominal rms voltage peak
Risetime: 0.01 ±.002 microsecond
Falltime: 0.1 ±.002 microsecond
Pulsewidth: (50% amplitude points): ±0.01 microsecond.
Repetition rate (aperiodic): Not greater than 50 Hz.
Source energy capability: Not less than 50 j.

See Fig. F9 for waveform example.

6. NOTES.

6.1 Total system characteristics. This document specifies selected characteristics of high voltage electric power in a high voltage, high power aircraft system. These characteristics are the result of the mutual influences of the electric power generation, distribution, and load equipment. Load equipment should be designed to minimize any deleterious reactions and effects it may have on power quality. It is not the intent of this document to specify the manner in which these characteristics are attained. Further detail specifications contain additional limits and constraints which are the responsibility of the designer to recognize in the context of total system limits.

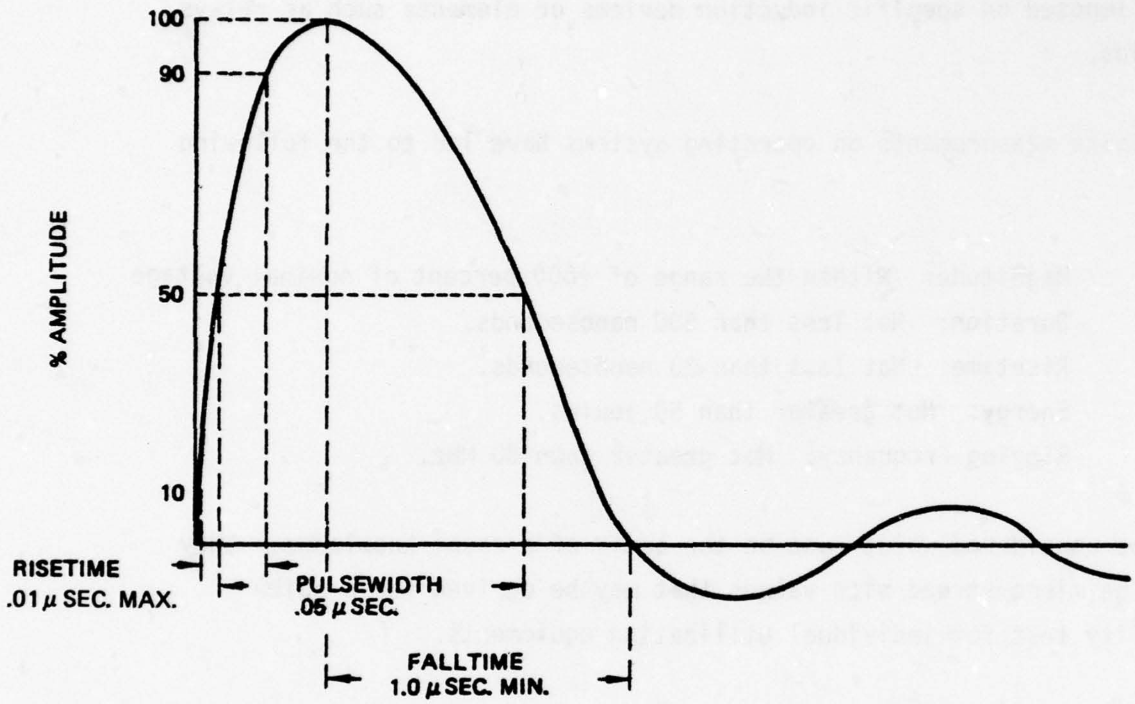


Figure F9: Example for Spike Waveform Showing Time Parameters (See 5.4.5.1)

6.2 Spikes. The random and periodic occurrence of voltage spikes superimposed on other voltage characteristics specified by this standard is acknowledged. Their impact on equipment may range from temporary degradation of performance to destruction of equipment. The predominance of their high frequency behavior, however, makes necessary the recognition of their potential influence as a form of electromagnetic interference. No spike suppression is explicitly imposed on specific induction devices or elements such as relays and solenoids.

Spike measurements on operating systems have led to the following estimates:

Magnitude: Within the range of +500 percent of nominal voltage
Duration: Not less than 500 nanoseconds.
Risetime: Not less than 20 nanoseconds.
Energy: Not greater than 50 joules.
Ringing Frequency: Not greater than 50 MHz.

These may be considered worst case on the basis of present knowledge. They are not to be misconstrued with values that may be derived for a spike susceptibility test for individual utilization equipments.

6.3 Power sensitivity and system conformance tests. Power sensitivity tests for individual utilization equipment must be developed further and adapted to a new standard to serve as a companion to this criteria document. It is also necessary to develop conformance testing methods and standards based on this criteria document with allowance for individual aircraft requirements. (*See 3.20.)

* In the context of this standard, and in the absences of correlation between individual equipment performance and that in a system, the inclusion of such tests is intended to indicate qualification and compatibility for subsequent system application.

6.4 DC distortion: individual equipment vs. system effects. Tests have disclosed that individual power source tests into dummy loads demonstrate higher frequency-component amplitudes than are indicated by Fig. F6. It is important to recognize this fact in connection with 5.2.1.2, 5.4.5 and 6.3.

6.5 Amplitude modulation. Amplitude modulation effects are predominantly identified with periodic load changes. The resultant rms level is below that indicated by the ac distortion (Fig. F2) derived as the covering envelope of measured spectral values. The off-carrier sideband components, however, are not required to fall off, in proportion to their frequency departure from the carrier.

6.6 International Standardization Agreement. Certain provisions of this standard are subject to international standardization agreements: NATO STANAG 3456, NATO STANAG 3516, ASCC Air Standard 12/10, and Air Standard 12/19. When amendment, revision or cancellation of this standard is proposed, that will affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels, including departmental offices, if required.

APPENDIX G

POWER SOURCES

POWER SOURCES, HIGH POWER, HIGH VOLTAGE,

GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope - This specification covers the general requirements for high voltage, high power, short lifetime power sources for use in airborne equipment.

1.2 Power Sources - The power sources are defined as electromagnetic machines that generate electric power with all ancillary equipment necessary to make it a functional unit, when integrated with the prime energy source or supply and output equipment for conversion and usage of the electric power. Unless otherwise specified, the duty cycle shall consist of (1) start-up from a static, de-energized state upon demand to rated output within a 1.0 second period with sudden application of the load, (2) transmission of electric power to the conversion equipment for five minutes minimum, and (3) sudden removal of 1.0 per unit load.

1.3 Classification - The power sources shall be of the following types and classes as specified:

Type 1 - Magnetohydrodynamic generator
- Class A - High voltage, 5-10KV DC
- Class B - Low voltage, 2-5KV DC

Type 2 - Alternating current generators
- Class C - High voltage, 40KV DC rectified
- Class D - Intermediate voltage, 20KV DC rectified
- Class E - Low voltage, 537/1000 volts AC

The power requirements will be defined in the detailed specification.

2. REQUIREMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATION

FEDERAL

BB-H-1168	-	Helium, Technical Grade
BB-S-1419	-	Sulfur Hexafluoride, Technical Grade
L-P-513	-	Plastic Sheet, Laminated, Thermosetting, Paper-Base, Phenolic Resin
QQ-S-571	-	Solder, Tin Alloy; Tin-Lead Alloy; and Lead Alloy
PPP-B-566	-	Boxes, Folding, Paperboard
PPP-B-601	-	Boxes, Wood, Cleated-Plywood
PPP-B-621	-	Boxes, Wood, Nailed and Lock-Corner
PPP-B-636	-	Boxes, Shipping, Fiberboard
PPP-B-640	-	Boxes, Fiberboard, Corrugated, Triple-Wall
PPP-B-676	-	Boxes, Setup
PPP-T-60	-	Tape, Packaging, Waterproof
PPP-T-76	-	Tape, Pressure-Sensitive Adhesive Paper, (for Carton Sealing)
VV-I-530	-	Insulating Oils

MILITARY

MIL-I-10	-	Insulating Materials, Electrical, Ceramic, Class L
MIL-M-14	-	Molding Plastics and Molded Plastic Parts, Thermosetting
MIL-W-76	-	Wire and Cable, Hookup, Electrical, Insulated
MIL-P-116	-	Preservation-Packaging, Methods of
MIL-P-997	-	Plastic Material, Laminated, Thermosetting, Electrical Insulation: Sheets, Glass Cloth, Silicone Resin
MIL-D-1000	-	Drawings, Engineering and Associated Lists
MIL-B-5087	-	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-E-5400	-	Electronic Equipment, Aircraft, General Specification for

MIL-F-5504 - Filter and Filter Elements, Fluid Pressure, Hydraulic Micronic Type

MIL-F-5591 - Fastener, Panel

MIL-L-7808 - Lubricating Oil, Aircraft Turbine Engine, Synthetic Base

MIL-M-7969 - Motors, Alternating Current, 400 Hz, 115/200-Volts System, Aircraft, Class A and Class B, General Specification for

MIL-F-14256 - Flux, Soldering, Liquid (Rosin Base)

MIL-P-15037 - Plastic Sheet, Laminated, Thermosetting, Class-Cloth Melamine-Resin

MIL-P-15047 - Plastic-Material, Laminated Thermosetting, Sheets, Nylon Fabric Base, Phenolic-Resin

MIL-W-16876 - Wire, Electrical, Insulated, High Temperature

MIL-P-18177 - Plastic Sheet, Laminated, Thermosetting, Glass Fiber-Base, Epoxy Resin

MIL-C-26074 - Coating, Electrodeless Nickel, Requirements for

MIL-C-45662 - Calibration System Requirements

MIL-W-81381 - Wire, Electric, Polyimide Insulated, Copper and Copper Alloy

(See detailed specification for list of associated specification sheets or military standards.)

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage

MIL-STD-147 - Palletized Unit Loads on 40" x 48" Pallets

MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts

MIL-STD-446 - Environmental Requirements for Electronic Component Parts

MIL-STD-454	-	Standard, General Requirements for Electronic Equipment
MIL-STD-461	-	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-462	-	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-470	-	Maintainability, Program Requirements
MIL-STD-471	-	Maintainability Demonstration
MIL-STD-781	-	Reliability Tests, Exponential Distribution
MIL-STD-785	-	Reliability Program for Systems and Equipment Development and Production
MIL-STD-831	-	Test Reports, Preparation of
MIL-STD-882	-	System Safety Program for System and Associated Subsystems and Equipment, Requirements for
MIL-STD-810	-	Environmental Test Methods
MIL-STD-1285	-	Marking of Electrical and Electronic Parts
MIL-STD-1540	-	Test Requirements for Space Vehicles
MS 33586	-	Metals, Definition of Dissimilar

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications - The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

NEMA Publication No. 109	-	AIEE-EEI-NEMA Standard Basic Insulation Level
ASTM-A120	-	Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless Pipe for Ordinary Uses
ASTM-A181	-	Rolled or Forged Steel Pipe Flanges, Forged Fittings, and Valves on Parts for High-Temperature Service

ASTM D1868	-	Detection and Measurement of Corona Pulses in Evaluation of Insulation Systems
ANSI B16.36-1975	-	Steel Orifice Flanges, Class 300, 600, 900, 1500 and 2500
ANSI B31.1-1973	-	Power Piping
ANSI C57.1200-1973	-	General Requirements for Distribution, Power and Regulating Transformers
APPENDIX A	-	High Voltage Cable Criteria Document
APPENDIX C	-	High Voltage Capacitor Criteria Document
APPENDIX F	-	Aircraft High Voltage Electric Power Characteristics Criteria Document
AFAPL-TR-76-41	-	High Voltage Design Guide for Airborne Equipment

NATIONAL BUREAU OF STANDARDS

Handbook H28	-	Screw-Thread Standards for Federal Services
Handbook MCIC-HB-04	-	Handbook on Materials for Super Conducting Machinery

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.)

3. REQUIREMENTS

3.1 <u>Description</u> - This specification covers the requirements for high power, high voltage, short lifetime electric power sources for use in or in conjunction with airborne equipment. The power sources shall be complete with accessories and auxiliary equipment as specified herein and required for operation as specified herein. The power sources shall be rated as follows:

a. Alternating current generator, class C, D or E, power output and operating time shall be as defined in the detailed specification.

b. Direct current output, magnetohydrodynamic generator, class A or B, power output and operating time shall be as defined in the detailed specification.

c. Duty cycle - A duty cycle of 2.5 minutes per hour is required for each class generator.

All auxiliaries shall be suitable for operation from either the 400 Hz airplane power system or from the output of the selected power source.

3.1.1 <u>Reliability</u> - The power source shall have a reliability of 100 hours accumulative operating time between failures, using accept/reject criteria of MIL-STD-781, test plan IVa.

3.2 <u>Specification sheets</u> - The individual equipment requirement shall be as specified herein and in accordance with the applicable detail specification sheets. Whenever the requirements of this specification and the detail specification or standard conflict, the requirements of the detail specification or standard shall govern. Any deviation from

this specification or from subsidiary specifications or standards, where applicable, must be specifically approved in writing by the procuring activity.

3.2.1 First article - When specified, the supplier shall furnish a complete power source for first article inspection and approval. Unless otherwise specified, the first article shall consist of one complete power source, including auxiliary cooling and control equipment.

3.2.2 Information to be furnished with first article - The applicable information outlined in 6.2 shall be furnished with the first article, together with any other pertinent information as required by the Government.

3.3 Materials and components - Materials and components not definitely specified shall be selected by the contractor and shall be subject to all provisions of this specification.

3.3.1 Selection of materials, parts, and processes - Materials, parts, and processes shall conform to applicable Government specifications. Materials conforming to contractor's specifications may be used provided the specifications are approved by the Government and contain provisions for adequate tests. The use of contractor's specifications will not constitute waiver of Government inspection.

3.3.1.1 Substitution of materials - If the supplier desires to substitute another material for a specified material or fabricated part, he shall submit a statement to the Government describing the proposed substitution, together with evidence to substantiate his claims that such substitute is equivalent. At the discretion of the Government, test samples may be required to prove the suitability of the proposed substitute. Before such substitutions are made, approval for each substitution shall be obtained in writing from the Government.

3.3.1.2 Flammable materials - Insofar as practicable, materials used in the construction of the power source shall be nonflammable and nonexplosive.

3.3.1.3 Thermal and sound insulating material - Unless otherwise specified (see 6.2.1), the thermal and sound insulating material shall conform to the following requirements:

a. Noncapillary, nonhygroscopic, and free from perceptible odors.
b. Resistant to attack by vermin and mildew.
c. Fire retardant, unaffected by battery electrolyte or petroleum derivatives.
d. Capable of maintaining its shape, position, and consistency inherently or by suitable retaining methods under conditions of vibration and temperature specified herein.
e. Resistant to or protected from abrasion, if exposed, and shall be replaceable, and bondable to metal.

3.3.1.4 Corrosive materials - Corrosive materials used in any of the manufacturing processes shall be removed or neutralized so that no corrosion will result from such use. Insofar as practicable, materials used in the construction of the power source shall be noncorrosive.

3.3.2 Electrical insulating materials - Electrical insulating materials used, including plastics, fabrics, and protective finishes, shall be moisture resistant and shall not support fungus growth. The nonmetals shall not support combustion and shall not be adversely affected by weather, aircraft fluids, temperatures, and ambient conditions encountered during operation of the aircraft. Nonmetals may be treated to conform to this requirement.

3.3.2.1 Laminated phenolic - Laminated phenolic materials shall conform to MIL-P-997, L-P-513, MIL-P-15037 and MIL-P-15047. When electrical characteristics are involved, only natural uncolored materials shall be used.

3.3.2.2 Molded phenolic or melamine - Molded phenolic or melamine materials shall conform to MIL-M-14.

3.3.2.3 Ceramic (external use) - Ceramic materials shall conform to MIL-I-10.

3.3.2.4 Laminated plastic sheet - Laminated plastic sheet, epoxy, shall conform to MIL-P-18177.

3.3.2.5 Insulating Fluids - Insulating oil and gases shall be free of particles. Samples shall be evaluated to assure the virgin fluid is free of particles. Provisions shall be provided to check purity of fluid and for replacement of fluid.

3.3.2.5.1 Coolants - Coolant fluids circulated through passages or around conductors shall have adequate spacing to allow unrestricted circulation. Insulated conductors shall have smooth void-free construction to prevent cavitation, or stagnation of the fluid at all temperatures covered by this specification.

Coolants may be passed through hollow strands (conductors) provided the electrical characteristics of the part is not electrically, thermally, or mechanically deteriorated.

3.3.2.5.2 Filtering - Filters shall be installed in the coolant and insulating loops which will remove solid waste products. Provision shall be made for chemically checking the coolant for impurities. Refurbishment of fluids shall be made periodically to assure non-contamination.

3.3.2.6 Insulating gases - Insulating gases may be either pure or a mixture. Gas or gas purity shall be as specified by BB-H-1168, BB-S-1419 or equivalent, to assure the virgin material is free of impurities such as water.

3.3.2.6.1 Gas-filled units - When the unit is gas filled it shall be as specified in 4.12.1.2, and the leak rate shall not exceed 10^{-3} Pascal-cubic centimeter per second.

3.3.2.6.2 Pressure-vacuum transducer - A pressure-vacuum transducer shall be furnished for each pressurized sealed-tank and/or gas-oil-seal construction.

3.3.2.6.3 Liquid temperature transducer - A liquid temperature transducer shall be furnished for units of the sealed tank liquid filled construction.

3.3.2.6.4 Pressure-vacuum bleeder - A pressure-vacuum bleeder device shall be set to operate at the maximum operating pressure (positive and negative) indicated on the nameplate. Effluent gases/liquids shall be ported overboard the aircraft.

3.3.2.6.5 Tanks - Tanks shall be designed for vacuum filling in the field. A pressure relief device shall be provided on the cover. Maximum operating pressures (positive and negative) for which the unit is to be operated shall be indicated on the nameplate.

3.3.2.6.6 Fans, pumps and control - The equipment for automatic control of fans or pumps for forced air cooled or liquid cooled units shall be thermally controlled with a manual override switch in parallel with the automatic control. Contacts and sensors shall be enclosed inside the tank.

3.3.2.7 Materials quality - Molded, ceramic and laminated materials shall be free of flaws such as cracks, delaminations and voids. Sample lots shall be evaluated to assure flaws do not exist in the virgin material or processed materials. Bolting and clamping shall be designed to prevent delamination or cracking of large, thick, laminated and molded parts during installation of parts and wiring.

3.3.3 Metals - The metal materials for each part shall be as specified (see 3.2). When a definite metal is not specified, a metal which will enable the part to meet the requirements of this specification shall be used. Acceptance or approval of a constituent material shall not be construed as a guarantee of the acceptance of the finished product.

AD-A069 473   BOEING AEROSPACE CO   SEATTLE WASH   F/G 9/5

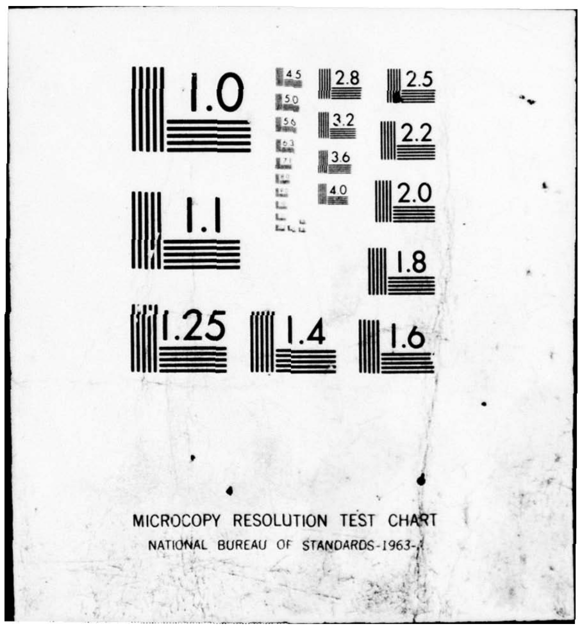
HIGH VOLTAGE SPECIFICATIONS AND TESTS (AIRBORNE EQUIPMENT). (U)

APR 79   W G DUNBAR, W P KOENIG   F33615-77-C-2054

UNCLASSIFIED   AFAPL-TR-79-2024   NL

5 OF 6

AD
A069473


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

3.3.3.1 The following are acceptable corrosion-resisting metals (as distinguished from corrosion-resisting treatments).

a. Corrosion-resisting steel which contains a minimum of 12 percent chromium.
b. Copper
c. Aluminum
d. Aluminum alloys which do not contain more than 0.4 percent copper.
e. Brass
f. Bronze
g. Beryllium-copper
h. Copper-nickel alloys
i. Nickel-copper alloys
j. Titanium
k. Inconel

3.3.3.2 <u>Treatments</u> - The following are corrosion-resistant treatments that will be acceptable:

a. Sherardizing
b. Galvanizing
c. Electrodepositing with cadmium, chromium, copper, nickel, silver, or zinc.
d. Aluminizing
e. Chromizing
f. Electrodeless nickel per MIL-C-26074

3.3.3.3 <u>Corrosion resistance</u> - Materials shall be of a corrosion-resisting type or suitably processed to resist corrosion. Any corrosion that causes malfunctioning of the equipment, shortening of life, impairment of use, or impairment of ease of replacement of parts shall be cause for rejection.

3.3.3.4 <u>Dissimilar metals</u> - Dissimilar metals, as defined by Military Standard MS33586, when used in contact with each other, shall be protected against electrolytic corrosion, and shall have a low-impedance path to radio-frequency currents as specified in requirement 16 of MIL-STD-454.

3.3.3.5 <u>Solder and soldering flux</u> - Solder, when used, shall be in accordance with QQ-S-571. Soldering flux shall be in accordance with MIL-F-14256.

3.3.3.6 <u>Screws, nuts, bolts, and washers</u> - All mounting and terminal screws, nuts, bolts, and washers shall be of corrosion-resistant material or shall be protected against corrosion. All nuts, bolts, and screws shall have standard screw threads in accordance with NBS Handbook H28.

3.3.3.7 <u>Corona protection</u> - All mounting and terminal screws, nuts, bolts, and washers near a high voltage part shall have rounded configuration to eliminate corona. Screw threads shall not exist in parts subjected to high field concentration.

3.3.4 <u>Toxic materials</u> - Materials which are known to produce harmful toxic effects under any conditions, including fire, shall not be incorporated in the design without prior approval of the procuring activity.

3.3.5 <u>Standard parts</u> - Standard parts shall be used wherever they are suitable for the purpose, and shall be identified on the drawings by their standard part number. In the event there is no suitable standard part in effect on the date of invitation for bids, commercial parts may be used provided they conform to this specification and can meet the same parts screening procedure as for standard parts.

3.3.6 <u>Nonstandard parts and materials</u> - A request for the use of nonstandard parts and materials shall be submitted to the procuring activity for approval prior to their use in the design and construction of the equipment.

3.3.7 <u>Interchangeability</u> - All parts having the same manufacturer's part number shall be directly and completely interchangeable with respect to installation and performance. Changes in manufacturer's part numbers shall be governed by the drawing number requirements of MIL-D-1000.

3.3.8 <u>Wire</u> - Internal wiring of a power source is considered to be all the interconnecting wiring within the power source enclosure.

3.3.8.1 Insulated wire - When insulated wires are used in wire terminals, the wire shall be of the types and sizes covered in MIL-W-76, MIL-W-16878, MIL-W-81381 or the H.V. cable criteria document. Government approval shall be required when other types and sizes of insulated wires are used as terminals.

3.3.8.2 Wire support - All wires, cables, and buses shall be supported and arranged so that they will withstand abrasion, flexing, and vibration. Clamping shall be such that it will not damage the insulation.

3.3.9 Thermal stress - Materials, metals and insulations, subjected to cryogenic temperatures shall be of a type suitably processed to resist deformation, cracking, or delamination when cycled from room ambient temperature to cryogenic temperature and vice versa, and shall maintain their electrical, conducting, and insulating properties throughout the temperature range.

3.3.9.1 Resistance to deformation, cracking, and delamination shall be required only in samples of representative size, shape and construction, only when subject to preloads representative to those expected in service, and only when subject to rates of temperature variation not in excess of 30 percent greater than can reasonably be expected in service.

3.3.10 Fasteners

3.3.10.1 Panel fasteners - Panels, inspection doors, and plates for all components, which are subject to frequent operation and removal, shall have corrosion-resistant fasteners conforming to MIL-F-5591, type II, style 1, class and size as required.

3.3.10.2 Electrical fasteners - Each electrical fastener, and other electrical hardware shall be made of corrosion-resistant material or shall be treated to be corrosion resistant. Fasteners (bolts, screws, studs, or other fasteners) shall not generally be depended on to carry current; they shall serve merely to hold current-carrying parts (lugs, terminals) in firm contact with each other. Where flow of current through a stud cannot be avoided, the stud and all its associated hardware (nuts, locking devices, washers, or other hardware) shall be made of corrosion-resisting material. Positive means (such as pins, or square shanks) shall be provided to prevent

turning of studs in their mountings when nuts are tightened or loosened; lockwashers which depend on friction or spring action will not be acceptable for this purpose. Unused length of threads on studs (or screws used as studs) shall not exceed half the diameter of the stud.

3.3.10.3 Other fasteners - Each fastener (screw, stud, bolt, pin, or other fastener) shall be equipped with a suitable locking device to prevent loosening due to vibration. Locking shall be by locknuts, castellated nuts with cotter pins, lockwashers, lock wire, or lock plates. No swedging, peening, or staking of parts subject to removal or adjustment will be permitted. Lockwashers shall be captive on nuts, machine screws, capscrews, and bolts, when the nominal size is less than 1/4-inch diameter. Fasteners and associated hardware (nuts, locking devices, washers, or other hardware) shall be made of corrosion-resistant material, or shall be provided with a corrosion-resistant treatment. Self-locking nuts may be used on removable through bolts in lieu of a lockwasher.

3.4 Alternating current generator performance

3.4.1 Design and construction - The article shall conform to the applicable specifications and standards or to the detailed specifications.

3.4.2 Functional description - The ac generator shall provide high voltage power to a selected aircraft load upon demand, without arcing, during ground testing and flight operation. The ac generator prime mover shall be an aircraft power source or an equivalent ground power unit.

3.4.3 Generator performance requirements - The generating system, including the auxiliary components, shall perform as required herein. Unless otherwise specified, these requirements apply at the terminals, with the prime mover input speed from 1.0 to 1.1 PU rpm. Operation up to 1.1 PU rpm will be demonstrated with steady-state loads up to 1.1 PU MVA.

3.4.3.1 Speed range - The speed range of the generator input shaft will be 1.0 to 1.1 PU rpm.

3.4.3.2 Load - The generator shall be capable of supplying the following loads at the input speeds and for the time intervals indicated.

3.4.3.2.1 Continuous load - The system shall be capable of supplying continuously for five minutes a load of 1.0 PU MW measured at the dc side of a Graetz bridge connected directly to the generator terminals.

3.4.3.2.2 Overload - The system shall be capable of supplying the following overloads under the conditions specified below:

a. 1.25 PU MVA for 10 seconds at 1.0 to 1.1 PU rpm
b. 1.5 PU MVA for 1 second at 1.0 to 1.1 PU rpm

Overload capability may be an over-current capability without substantial over-voltage.

3.4.3.2.3 Short circuit - For any steady initial condition within the capability of the system, the generator shall remain substantially physically intact following sudden application of a short circuit at the terminals. Subsequent operation without inspection and repair shall be required.

3.4.3.3 Symmetry of construction - For all speeds and balanced loads within the full load rating of the generator, the phase voltage unbalance shall not exceed 2 percent. The phase separation of balanced loads shall be 120° ±2°.

3.4.3.4 Efficiency - The minimum efficiency at rated load for the generator system (includes exciter and coolant pumps) shall be 95% at full load.

3.4.3.5 Service life requirements

3.4.3.5.1 Useful life - The unit shall be designed for a useful life, including standby, storage and operation of 50,000 hours.

3.4.3.5.2 Flight line service - The unit shall operate a minimum of 100 flight readiness hours without repair or adjustment of any kind. Routine maintenance of coolants and fluids/liquid dielectrics is permissible for each flight.

3.4.3.6 Transient voltage characteristics - The average of the three phase voltages shall remain within the limits specified in Figure G1 during and following load and fault switching.

3.4.3.7 Voltage buildup - The voltage buildup transient shall not exceed the limit of Figure G1. Voltage shall recover to and remain within $\pm$ 5% of the final steady-state value, within 1 second maximum and shall be compatible with system over-voltage protection limits of paragraph 3.4.3.14.

3.4.3.8 Voltage recovery time - In addition to the recovery limits of Figure G1, the voltage shall recover to and remain within 0.05 PU volts L-N of the final value within one second after application or removal of a step load starting from 0.1 PU MVA to 1.1 PU MVA or from 1.1 PU MVA to 0.1 PU MVA.

3.4.3.9 Voltage regulation - Voltage regulation shall be $\pm$0.05 PU volts maximum over the rated speed, power factor, and ambient temperature range at loads from zero to 1.2 PU MVA.

3.4.3.10 Generator shock load - Sudden application or removal of any load up to 1.0 PU load from the generator drive input at any constant input speed from 1.0 PU to 1.15 PU rpm shall not cause the real load to exceed the average real load by more than 0.1 PU MVA.

3.4.3.11 Starting performance - The generator after having been stabilized at any outside ambient from -55°C to +55°C temperature, shall be capable of the following starting performance. After having the input speed brought up to 1.0 PU rpm within a 1.0 second period, the generator shall, at the end of the 1.0 second period, meet the following requirements under any load up to 1.0 PU MVA:

a. It shall be within ±0.05 Hertz of the steady state operating frequency requirements:

   1. Within 1.0 second after obtaining steady-state speed where the ambient temperature is +50°C at the beginning of the 1.0 second period.

   2. Within 2.0 seconds after obtaining stead-state speed where the ambient temperature is -55°C at the beginning of the 2.0 second period.

3.4.3.12 Exciter - The excitation system shall be capable of supplying steady state excitation power. The excitation system shall be capable of rapidly forcing the alternator field toward zero following a load loss or a short-circuit fault. Generator start-up characteristics and shut-down characteristics shall be considered in the excitation system design (see figure G1). The unit may have a power input from the airplane auxiliary power system.

3.4.3.13 General control requirements - All control circuits shall be designed to prevent system disturbances during normal system operation. The design shall guard against the possible effects of extraneous voltage pickup within the system and associated wiring.

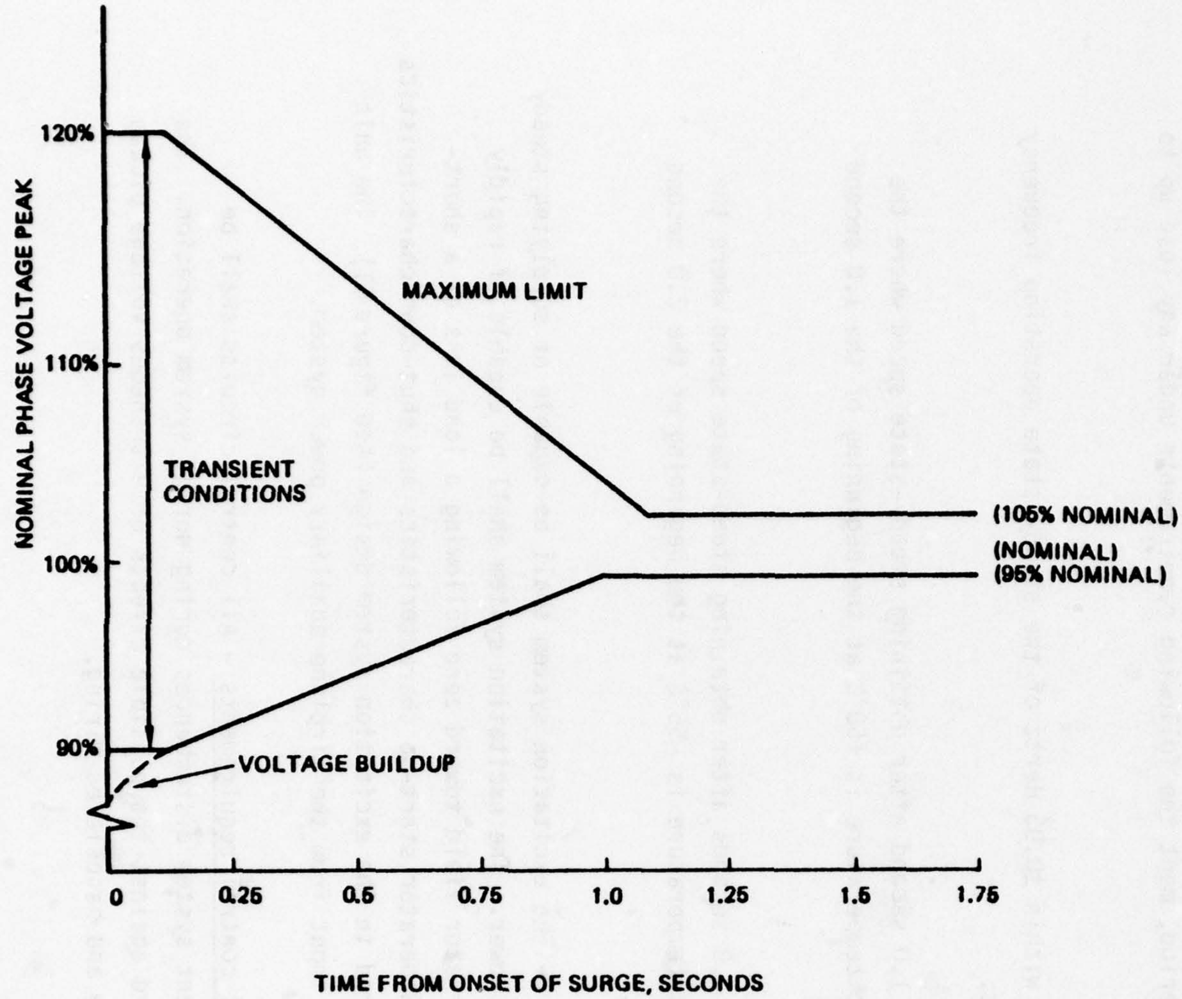


Figure G1: Envelope of AC Voltage Surge (See 5.1.2.1)

3.4.3.14 Control functions - The term "relay" is used in this section to simplify description of function, and does not necessarily refer to an electro-mechanical device. The following control functions shall be provided:

a. Generator field control and indication

b. Anti-cycling and lockout control

c. Power ready relay control

3.4.3.14.1 Generator field control and indication (GCR) - A relay shall be provided to make and break the generator exciter field circuit or voltage regulator power supply circuit. This relay shall be operated by: 1) internal protective circuits, and 2) external safety switches.

A time delay shall be provided so that this relay is tripped 2 to 3 seconds following actuation of the safety switches.

3.4.3.14.2 Anti-cycling and lockout control - The Control System shall contain suitable lockout circuits to prevent cycling of the generator field control if a system fault exists and an external control switch is held in the "close" position.

Anti-cycling relays shall be provided to prevent cycling of circuit breakers and contactors whenever more than one switch is held in the "close" position.

3.4.3.14.3 Power ready control - The power ready control shall inhibit the closure of relays or circuit breakers if the power quality of the power source - generator or external power supply, is beyond the abnormal power quality limits. Over voltage, under voltage, over frequency and under frequency shall be the determining factors of power quality determination.

3.4.3.14.4 Underspeed trip circuit - The underspeed trip circuit shall be activated by a contact type switch. The contacts of the underspeed switch shall not be subject to contact chatter or mechanical failure (such as fatigue failure at soldered connections) when operating in a vibration environment.

3.4.3.14.5 Overspeed/underspeed - A device shall be included in the power input to monitor rotor speed. The output from this device shall operate a protection circuit in the Generator Control Unit to provide overspeed and underspeed protection.

3.4.3.14.6 Charge pressure switch - A charge pressure switch shall be provided to actuate warning lights on the airplane instrument panel when the oil pressure or coolant pressure reaches the minimum safe value. The

warning light and all associated electrical wiring will be furnished as part of the electrical power system.

The switches shall be of the contact type. The contacts of the switches shall be open during normal operation and shall not be subject to contact chatter when operating in a vibration environment.

3.4.3.15 Magnetic sump plug - A magnetic oil-sump plug shall be provided in the fluid circuits to attract any loose magnetic particles. The plug shall be designed such that the magnetic particles can be inspected without loss of sump fluid. The magnetic field of the plug shall be in a direct path of the fluid flow.

3.4.3.16 Lubrication and cooling system - The generator assembly shall include lubrication and cooling systems which shall satisfactorily lubricate and cool the generator under the operating conditions specified herein.

3.4.3.16.1 Oil, gas, and other fluid coolant filtration - Oil and coolant filters shall be incorporated into the charge systems of the generator if oil filtration is required for proper operation. The filter shall perform as required by MIL-F-5504.

The oil and coolant filter shall have a minimum service life of 100 hours operation. An external indication of excessive pressure drop shall be provided. The filter shall be arranged such that the filter element can be removed and replaced without removing any other part of, or connection to, the oil/coolant circuits.

3.4.3.16.2 Seals - The generator shall have seals for holding oil and other fluid coolant leakage to a minimum. Leakage shall not exceed the following:

a.	Input shaft seal leakage	1 cc/hr
b.	Generator external leakage at static seals	Oil wetting may occur, but no drops shall form

c. Static (standby) total leakage: Same as above at 6 - 10 psi

d. Static total leakage at 6" head: 1 cc/hr

3.4.3.16.3 Reservoir - The generator assembly shall have an integral reservoir and self-sealing fill overflow boss. Visual means shall be provided to indicate both "full" and "refill" oil and other fluid coolant levels while the generator is at the ground installation attitude. For ground installation the generator center line may be inclined up or down 4° from the horizontal. A drain port shall be provided to permit draining of the reservoir and drive case.

3.4.3.17 Helium - Superconducting generators shall use liquid helium for cooling the superconductor. Helium boil-off during Dewar charging, standby, and system operation shall be vented overboard or reclaimed. Provisions shall be made to prevent accumulation of helium inside any airplane compartment while on the ground or in flight.

3.4.3.17.1 Detectors - Helium leak detectors shall be placed on-board the airplane in critical high voltage areas to detect and send warning signals to the control panel in case of helium leaks.

3.4.3.18 Electrical components

3.4.3.18.1 Explosion-proofing - All electrical components, except hermetically sealed or potted units, shall be explosion proof as defined in MIL-STD-810, to prevent ignition of any explosive mixture which may surround the prime mover.

3.4.3.18.2 Electrical connector - All electrical leads shall terminate in electrical connectors.

3.4.3.19 Main terminal block - The main terminal housing shall provide four high voltage connectors for the 3 phase output and neutral connections.

The terminal housing shall be of a fire-resistant, self extinguishing material. Suitable barriers shall be provided between terminals. The connectors shall be arranged to positively prevent routing of the line leads directly over the neutral terminal. The generator connectors shall be of the type described in the High Voltage Connector Criteria Document. The connectors shall be permanently marked T1, T2 and T3, respectively, for the three output phases, and N for the neutral.

3.4.3.19.1 Main terminal housing cover - A cover, made of non-metallic, fire-resistant, self-extinguishing material, shall be provided for the main terminal housing. These terminal covers shall be removable and replaceable from either side of the generator without disturbing the lay of the cables to the terminals.

3.4.3.19.2 Connector - All electrical connections to the generator, other than the 3 phase, four-wire main output connections, shall be low voltage connectors.

3.4.3.20 Solid-state devices - Exciter solid-state devices shall preferably be of a standard commercial type. Design shall be such that even during system fault conditions the current and voltage to which the devices are subjected does not exceed 60% of their rating; a suitable suppression device may be used to meet this requirement. The generator shall not be further damaged as a result of a solid-state device failure.

3.4.3.21 Maintenance - The design of the generator shall be such as to facilitate servicing, replacement and repair. Replacement of the exciter output solid-state device shall not require balancing of the rotor, or cutting and rebrazing of the leads.

3.4.3.22 Position - The power source shall meet the performance requirements of this specification when operating under conditions a. through d. below:

a. Level position with the power source inclined up to 30° to either side . . . . indefinitely.

b. 0° - 60° climbing or diving angle with the power source inclined up to either side . . . . 60 seconds.

c. Negative 1.0 g operation . . . . 60 seconds.

d. -6g maximum . . . . 5 seconds.

3.4.4 AC generator control unit requirements

3.4.4.1 Cooling air - No cooling air will be provided.

3.4.4.2 Operating position - the unit shall function properly regardless of orientation.

3.4.4.3 Circuit separation - Control circuitry should be electrically, functionally and physically isolated insofar as practicable from the voltage regulator and protective circuitry. Input and sensing protection and control leads should be separated from the voltage regulator connections. All power required for generator excitation under normal load, overload and fault conditions shall be supplied to the voltage regulator by the generator or dedicated power supply.

3.4.4.4 Voltage regulator section.

3.4.4.4.1 Voltage sensing - The voltage regulator shall sense and regulate the average of the three phase voltages. High-phase "take-over" or "limiting" shall be provided, if required, to limit the highest phase voltage under unbalanced load or fault conditions to the limits of paragraphs 3.4.3.6 through 3.4.3.11.

3.4.4.4.2 Excitation power - All power required for generator excitation under normal load, overload and fault conditions shall be supplied to the

voltage regulator by the generator or dedicated power supply. See paragraph 3.4.3.12.

3.4.4.4.3 Stabilizing - The voltage regulator shall be self-stabilizing. Feedback and/or stability circuits required to obtain system stability shall be contained within the voltage regulator. No generator stability windings shall be required.

3.4.4.4.4 Power and fault current limiting - The generator input power and fault current limiting circuit, if required to meet the requirements of paragraph and 3.4.3.2 shall be contained within the voltage regulator section.

3.4.4.4.5 Voltage adjustment - An internal adjustment shall be provided to permit the point of regulation no-load voltage to be adjusted in increments of not more than 50 volts. The setting means shall be so designed and constructed that it will not be displaced under any of the vibration conditions specified in paragraph 3.6.7.

3.4.4.4.6 Useful life - The unit shall be designed for a useful life of 50,000 hours operation, shelf and standby.

3.5 Magnetohydrodynamic generator

3.5.1 Design and construction - The article shall conform to the applicable specifications and standards or to the detailed specifications.

3.5.2 Functional description - The magnetohydrodynamic (MHD) generator shall provide a specified voltage, direct current, power load upon demand without interelectrode arcing, during ground testing and flight operations.

3.5.3 Performance requirements - The generating system, including the auxiliary components, shall perform as required herein. Unless otherwise specified, these requirements shall be at the power output terminals.

3.5.3.1 Load - The generator shall supply the following loads for the time intervals indicated.

3.5.3.1.1 <u>Continuous load</u> - The system shall be capable of supplying continuously for five minutes, to a fixed load resistance 1.0 ± 0.1 per unit MW.

3.5.3.1.2 <u>Overload</u> - The generator shall be capable of supplying the following overloads under the conditions specified below:

> 1.25 PU MW for 10 seconds. Increased load will be accomplished by decreasing load resistance.
>
> 1.5 PU MW for 1 second.

3.5.3.1.3 <u>Short circuit and open circuit</u> - From supplying continuous rated power at rated voltage the generator shall be capable of withstanding a short circuit or open circuit for a period of 1 second without harm to the generator or protection devices. The generator shall be protected from open circuit and short circuit conditions.

3.5.3.2 <u>Efficiency</u> - The ratio of thermal power input to electrical power output at rated load for the MHD generator system (including auxiliary supplies and equipment) shall be greater than 0.20.

3.5.3.3 <u>Service life requirements</u>

3.5.3.3.1 <u>Useful life</u> - The unit shall be designed for a useful life, including shelf, standby and operation, of 50,000 hours.

3.5.3.3.2 <u>Flight line service</u> - The unit shall operate a minimum of 100 flight readiness hours without major overhaul. Routine maintenance of coolants, gaseous/liquid dielectrics and channel are permissible for each flight.

3.5.3.4 <u>Voltage requirement</u> - The required voltage shall be 1.0 ± 0.05 PU volts at 1.0 ± 0.1 PU load current.

3.5.3.4.1 Voltage - With a constant resistance load, the load voltage shall rise and remain within 1.0 ± 0.05 PU volts of the final steady state voltage 1 second after start-up command. The system voltage limits shall be compatible with the system over-voltage, under-voltage protection devices of paragraph 3.5.3.1.1.

3.5.3.4.2 Voltage recovery time - The generator shall recover and remain within 1.0 ± 0.05 PU volts within one second after application of a step load from 0.1 PU to 1.0 PU MW.

3.5.3.4.3 Transient voltage characteristics - The load voltage shall remain within the limits specified in Figure G2 during and following load and fault switching.

3.5.3.5 Starting performance - The generator system when stabilized at any external temperature of -55 to +85^{o}C shall perform according to all other requirements defined in paragraph 3.5.

3.5.3.6 Magnet - All power required for the generator magnet shall be supplied by an auxiliary airborne power source or switched ground support power supply.

3.5.3.6.1 Cryogenic magnets - The cryogenic magnet shall use helium as a coolant. The Dewar shall be active during flight and ground tests and instrumentation and monitors shall be active to assure the cryogen is in a fluid state. Helium bubbles are unacceptable in the magnet.

3.5.3.6.2 Seals - The magnet, plumbing and Dewar shall be sealed to minimize leakage. Coolant leakage shall not exceed 1 cc/hr at standard temperature and pressure for the total system.

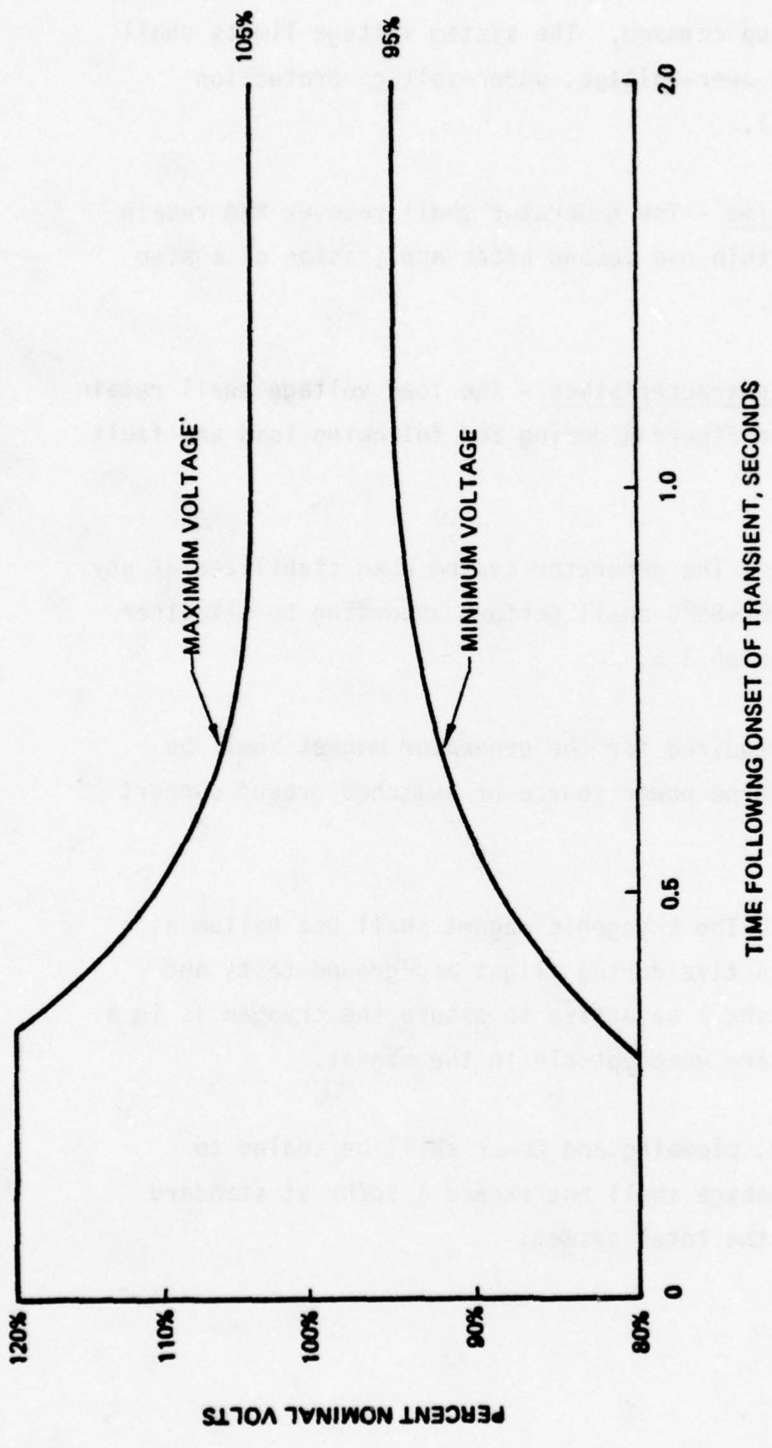


Figure G2: DC Limits for Constant Overvoltage or Undervoltage (See 5.2.3)

3.5.3.6.3 Exhaust gas - Expended helium and other gases shall be ported overboard.

3.5.3.6.4 Magnet start and stop - The magnet excitation shall be applied in a time-linear fashion with no impulses. The radiative effects of the magnetic field increase/decrease shall be contained within the magnet. External magnetic field fringe effects shall be less than that stated for the electromagnetic compatibility limits; see paragraph 3.5.3.6.5.

3.5.3.6.5 Shielding - A magnetic shield capable of reducing the channel magnetic field to 100 gauss outside the channel shall be proved to protect sensitive instrumentation and electronic circuitry located within one meter of the magnet. Conducted and radiated interference produced outside the shield by the starting, stopping or operation of the magnet shall not exceed the requirement of Specification MIL-STD-461.

3.5.3.6.6 Retention of magnetism - The magnetic output shall not deteriorate more than 1% during the required life of the MHD generator due to age or as the result of handling, shocks, system faults, material deterioration or normal usage.

3.5.3.7 Tankage and storage - Tankage and stored materials, including fuel, shall be stored in containers designed to withstand hydrostatic pressure 2-1/2 times either the maximum operating pressure or pressure resulting from any single possible malfunction or transient.

3.5.3.7.1 Pipe, hose, and fittings - Pipe shall conform to ASTM Designation A120, with fittings that conform to ASTM Designation A181. Pressure piping systems shall be in accordance with ANSI B31.1.0 and B16.5, as applicable. Hose and hose fittings shall be used with piping systems where there is relative motion between parts. The hose and fittings shall be selected and sized for the pressures involved. The use of snap rings in conjunction with petroleum products liquid lines where snap ring failure would present a fire hazard is

prohibited. Piping which connects liquid systems shall be arranged to avoid any air pockets or undrained traps and shall have provision(s) for venting air after any part, subassembly, or component changeouts are made. All drain piping shall terminate through the side of the base of the set with an installed valve threaded for connection of an external pipe.

3.5.3.7.2 Pressure-vacuum bleeder - A pressure-vacuum bleeder device shall be set to operate at the maximum operating pressure (positive and negative) indicated on the nameplate.

3.5.3.7.3 Monitor - The monitor and display subsystem shall have provisions for signal processing, remote sensing, and display of information on an airborne display unit.

3.5.3.8 Cooling air - Cooling air will be provided during flight by RAM air, at temperatures as shown in Figure G3. On the ground, air will be provided by fans at temperatures as shown in Figure G4. This cooling air will under certain operating conditions contain small amounts of runway debris (sand, slush, rain).

The rated air flow will be defined in the detailed specification. The vendor proposal shall provide a rating chart showing cooling air flow requirements over the operating altitude and temperature ranges. The cooling air outlet duct shall be provided with a clamp attachment.

3.5.4 Control requirements - All control circuits shall be designed to prevent system disturbance during normal system operation. The design shall guard against the possible effects of extraneous voltage pickup within the system and associated wiring.

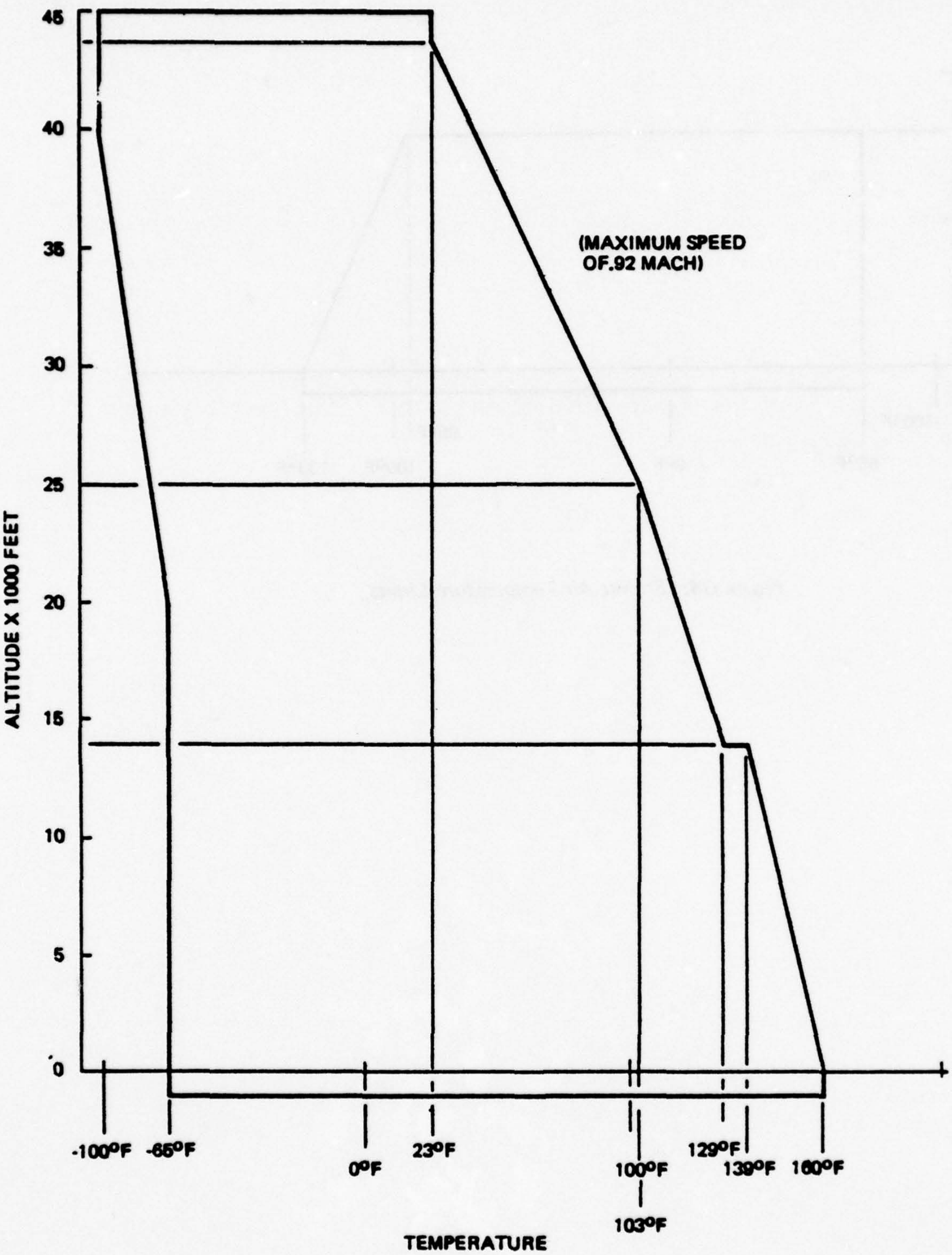


Figure G3: RAM Air Temperature Limits

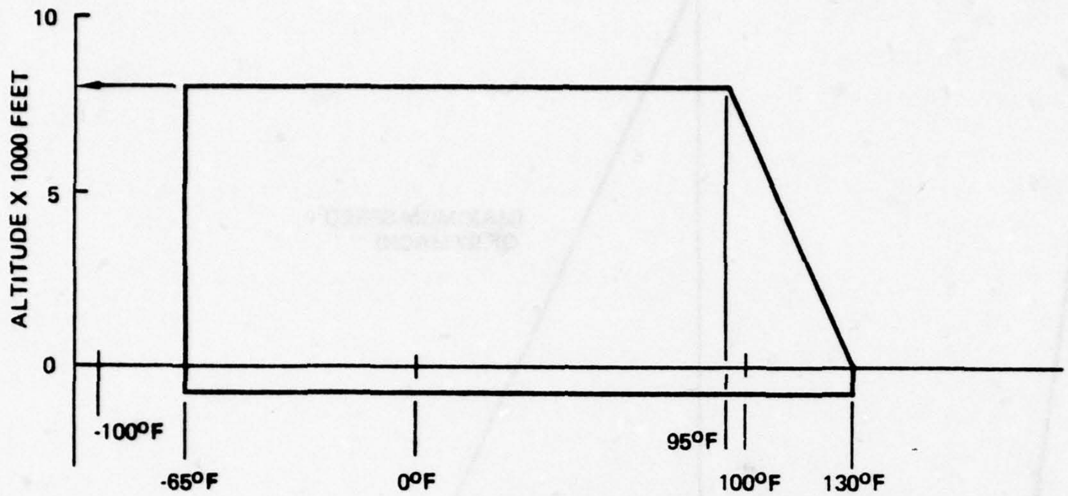


Figure G4: Blower Air Temperature Limits

3.5.4.1 Control function - Four control functions shall be provided:

a. MHD system control

b. Magnetic field protection

c. Fault isolating control

d. Power ready control

3.5.4.1.1 MHD system control - A controller shall be provided to turn the MHD generator "ON" and "OFF," to operate the system in the STANDBY and CHECKOUT modes, and provide protection for magnet current interruption during MHD generator operation.

3.5.4.1.2 Magnetic Field protection - A relay shall be provided to the generator magnetic field control circuit. This relay shall be tripped by internal protective circuits.

3.5.4.1.3 Fault isolation control - A relay shall be provided to transfer the magnetic field circuit from airplane power supply to an airplane emergency supply system should the airplane power system sustain a fault.

3.5.4.1.4 Power ready control - The power ready control shall inhibit the closure of relays or circuit breakers if the power quality of the airplane power system, external power source or generator is beyond the abnormal power quality limits. Overvoltage and undervoltage shall be the power quality determining factor.

3.5.5 Cooling - The generator cooling system shall satisfactorily cool the generator under operating and standby conditions specified herein. Coolant filters shall be incorporated into the charge system of the generator (see paragraph 3.4.3.16.1). Seals and reservoir shall meet the requirements specified in paragraphs 3.4.3.16.2 and 3.4.3.16.3.

3.5.6 Helium - The helium boil-off during charging, standby and flight shall meet the requirements of paragraph 3.4.3.17. Monitor, detector, and displays shall be as specified in paragraph 3.4.3.17.1.

3.5.7 MHD processing and control unit - An electronic processing and control unit shall be developed to sense and send control signals to the MHD generator system control, see 3.5.4.1. This unit shall be designed to receive inputs from the coolant loops, fuel tanks, seed supply, input air louvers, load voltage and current. The processor shall react to protect the MHD generator and load equipment against load system faults (open or short) or sustained transients as well as to govern normal operation. A direct interface shall be made to the airplane monitor and display unit.

3.5.8 Monitor and display unit - Signals from several sources shall be conditioned for display on visual electronic scopes or monitored for go, no-go panel lights. Items that shall be displayed include but are not limited to:

Load voltage
Load current
Load power
Fuel metering
Seed metering
Coolant temperature and level
MHD magnet temperature
MHD channel temperature
MHD magnet current
Combuster temperature
Propellant levels

3.5.9 Exhaust gases - MHD exhaust gases shall be ported in order not to impinge upon airplane structural surfaces or edges during airplane standby, during takeoff or landing, or flight.

3.5.9.1 Thrust - Exhaust gases shall be ported in a manner to give minimum torque to the normal airplane thrust pattern.

3.6 Operational conditions - The power source shall be designed to provide rated output under the following conditions or combination thereof, listed in the following subparagraphs.

3.6.1 Temperature and altitude - The power source shall meet the requirements of paragraph 3.5.3 when subjected to the following ambient temperature range:

a. Operating - The equipment shall be capable of operating at temperatures between $-20^{\circ}C$ to $55^{\circ}C$ at pressure altitudes from 1,000 feet below sea level to 40,000 feet above sea level. It shall be capable of operating for one five-minute cycle in an ambient temperature from $-55^{\circ}C$ to $71^{\circ}C$ at altitudes 1,000 feet below sea level to 40,000 feet above sea level. It shall be capable of withstanding a pressure drop from 15,000 feet altitude to 45,000 feet altitude in 15 seconds while operating.

b. Non-operating - The equipment shall be capable of continuous exposure to ambient temperatures from $-55^{\circ}C$ to $+71^{\circ}C$ at pressure altitudes from 1,000 feet below sea level to 40,000 feet above sea level.

c. Cycling - The equipment shall be capable of multiple 5 minute operating cycles at full load.

3.6.2 Humidity - The equipment shall be capable of operating at relative humidity ranging up to 100 percent, including conditions wherein condensation will take place on the equipment.

3.6.3 Sand and dust - The equipment shall be capable of operating under conditions of airborne sand and dust particles.

3.6.4 Salt spray - The equipment shall be capable of operating in an atmosphere containing salt-laden moisture.

3.6.5 Fungus - The equipment shall be capable of operating when exposed to fungi as encountered in tropical areas.

3.6.6 Shock - The article shall be free of leaks, cracks, bursting, or bulging of the cases when tested as specified in 4.11.7.

3.6.7 Vibration - When the article is tested as specified in 4.11.8 there shall be no leakage of fuel, coolants, or seed materials and no evidence of other physical damage such as cracks, bursting, or bulging c the structure.

3.6.7.1 Airplane vibration - The power source system and ancillary components shall be subject to the airplane vibration during ground standby, take-off and landing, and flight. Vibration modes and tolerances requirements are defined in the detailed specification.

3.6.7.2 MHD generator vibration - Vibration transmitted from the MHD generator to the airplane structure shall be limited to the values defined in the detailed specification. These parameters shall not be exceeded due to a short circuit or fault imposed upon the generator.

3.6.8 Flammability - When the article is tested as specified in 4.11.9, there shall be no evidence of violent burning which results in an explosive-type fire, and the coating material used on the article shall be self-extinguishing. The article shall not be considered to have failed, in the event that it is consumed by the applied flame, unless dripping of flaming material or an explosive-type flame has occurred. The article shall be considered to have failed only if an explosion or dripping of flaming material occurs, an explosive-type flame is produced, or if visible burning continues beyond the allowable duration of 3 minutes after removal of the applied flame. Material will be considered self-extinguishing if the following conditions are met:

a. The duration of visible flame does not exceed 3 minutes after removal of the applied flame.

b. There is no explosion, nor any violent burning which results in an explosive-type flame.

c. There is no dripping of flaming material from the power source under test.

3.6.9 Nuclear radiation - Exposure limits to nuclear radiation shall be specified in the detailed specification.

3.7 Lifting, moving, and jacking facilities

3.7.1 Safety factor - Lifting, moving, and jacking facilities shall be designed to provide a safety factor of 5. This safety factor is the ratio of the ultimate stress of the material used to the working stress. The working stress is the maximum combined stress developed in the lifting facilities by the static load of the component being lifted.

3.7.2 Lifting facilities - Lifting facilities shall be provided for lifting the cover separately, and also for lifting the internal assembly from the housing using four lifting cables.

Facilities for lifting the complete article (with the cover securely fastened in place) shall be provided. Lifting facilities shall be designed for lifting with slings at a maximum angle of 30 degrees with respect to the vertical. The bearing surfaces of the lifting facilities shall be free from sharp edges.

3.7.3 Moving facilities - The base of the article shall be mounted on a frame of heavy plate or shall have members forming a rectangle that will permit rolling in the directions of the centerlines of the segments.

3.7.4 Jacking facilities - Jacking facilities shall be located near the extreme ends of the junctions of the case.

3.7.5 Mounting - The points of support shall be so that the unit will withstand the variable orientation of the airplane.

3.7.6 Mounting studs - When specified (see 3.2), external mounting studs shall be provided with a flat washer and locknut, or with a flat washer, lockwasher, and a nut.

3.7.7 Mounting and terminal screws and mounting inserts - Screw threads shall be class 2A or 2B, as applicable (see 3.2), in accordance with Handbook H28. External screw threads, class 2 fit, shall, after receiving a finish, be capable of accepting a nut of class 2B fit and internal screw threads, class 2 fit, shall, after receiving a finish, be capable of accepting a screw of class 2A fit. Maximum installation torque shall be as specified in the detailed specification. Nuts shall run down to within two threads of mounting surfaces.

3.8 Electrical construction

3.8.1 Internal wire leads - Internal wire leads shall be attached to the internal component terminals or case by soldering, welding, brazing, or other method (e.g., lead-sweating on nylon-coated wires) in such a manner as to provide adequate electrical connection and mechanical strength. Where soft solder is used to provide the electrical connection, wire leads shall be anchored mechanically.

3.8.2 Wire bundle ties and clamps - Wire bundle ties shall have the knots either burnished or enameled. (See "High Voltage Design Guide for Airborne Equipment," Figure 53).

3.8.3 Terminals

3.8.3.1 Solder terminals - Solder terminals may be of any shape and shall be capable of complying with solderability requirements of this specification. The height of the solder terminal shall be considered as the maximum distance from the terminal mounting surface to the highest point, including the additional height obtained if semiflexible terminals are straightened. (It is not intended that the "hook" in the hook-type terminal be straightened from its normal hooked position). The type of terminal and the maximum size of wire which the terminal will accept externally shall be as specified (see 3.2).

3.8.3.2 Case as terminal - When the case is used as a terminal, any protective coating applied to the mounting surfaces shall be such as to provide a direct conducting path for an electric current from the case to the surface on which it is mounted.

3.8.3.3 Screw terminals - When specified (see 3.2), external screw terminals shall be supplied with two nuts, two flat washers, and one lockwasher. For cased units, the height of the terminal assembly shall be the distance from the free end of the screw to the terminal mounting surface. The type of terminal, size of screw thread, and the exposed length of threads ± 0.062 inch shall be as specified (e.g., screw, 0.164-32 UNC x 0.375) (see 3.2).

3.8.3.4 Terminal strength - When the article is tested as specified in 4.12.5, there shall be no evidence of loosening or rupturing of the terminals, or other mechanical damage. Bends shall not be considered as damaged unless surface cracking is evident. Except for flexible leads, there shall be no rotation of the terminals. Rotation of the external portion of the metallic portion of a "hook" type terminal exceeding 10 degrees shall not constitute a failure.

3.8.3.5 Bushings - The insulation level of line bushings shall be equal to or greater than the insulation level of the windings to which they are connected (see 4.12.6).

3.8.3.6 Terminal insulators - Terminal insulators shall be epoxy, glass, or ceramic.

3.8.3.7 Corona protected bushing insulator - When specified (see 3.2), terminals shall be supplied with a corona suppressor where the terminal and terminal hardware are shielded by an angle of at least 30 degrees by a corona suppressor cavity. Terminal hardware shall consist of two nuts, one flat washer, and one lockwasher, or shall consist of one flat washer, one lockwasher and one cap screw. The terminal post shall not have external threads below the corona suppressor in the bushing. Terminal post finish shall be 100 microns or smoother. The height of the terminal assembly shall be the distance from the top of the corona suppressor to the terminal mounting surface. The type of terminal shall be specified (see 3.2).

3.8.4 Connectors - Connectors shall be hermetically sealed, circular threaded, high voltage with solder or brazed contacts.

3.8.5 Solderability - When the article is tested as specified in 4.12.7, it shall meet the applicable criteria for terminal evaluation in the test method.

3.8.6 Resistance to soldering heat - When the article is tested as specified in 4.12.8, there shall be no softening of the insulation or loosening of the windings or terminals.

3.8.7 Potting, filling, or encapsulating material - The amount and coverage of potting, filling, or encapsulating material used shall be essentially the same for all units of a specified design. Potting, filling, or encapsulating material shall not flow from the case of the article during any of the applicable tests.

3.8.8 Grounding - The article shall be grounded by bonding the case(s) to the airplane structure. A common point ground shall be specified for bonding the power source and load in a manner to prevent circulating currents in the ground path, protect the equipment from electromagnetic pulses and lightening, reduce electromagnetic interference, and prevent electrostatic discharges harmful to personnel. A ground path shall provide a path with a current-carrying capacity equal to or greater than that of the input and output conductors.

3.8.9 Surge arrestors - When specified, a surge arrestor ground pod consisting of a tank ground pod, mounted near the high voltage terminals shall be available for surge protection.

3.8.10 Power cable clamping - Power cables shall be bundled and clamped in place at one meter intervals to avoid a whipping action during short circuit on sudden load application. Cable clamps shall not crush or distort the cable insulation (external or internal) yet hold the cable firmly in place. Cable clamps near high voltage shielded or unshielded cables shall be insulated, and all metal portions of the clamps shall be grounded. Metal edges shall be chamfered to eliminate voltage stress at the edge of the clamp.

3.8.11 Weight, size and configuration - The maximum allowable overall dimensions, general configuration and weight (dry and operating) of the complete power source with all attached accessories shall be as specified in the detailed specification (see 6.2).

3.9 High voltage design and test

3.9.1 Insulation resistance - When measured as specified in 4.13.1, the minimum insulation resistance shall be greater than the value specified for the insulation system in the applicable specification.

3.9.2 Dielectric withstanding voltage - When tested as specified in 4.13.2, there shall be no evidence of arcing, flashover, breakdown of insulation, or damage.

3.9.3 Partial discharges (when specified, see 3.2) - When tested as outlined in 4.13.3 or as specified (see 3.2), the partial discharge maximum magnitudes shall not exceed the values defined in the detailed specification for each component when tested at rated voltage.

3.9.4 Impulse - When tested as outlined in 4.13.4 or as specified (see 3.2), impulse voltages shall consist of and be applied in the following manner:

one reduced full-wave
two chopped waves
one full wave

Impulse tests shall be made without excitation.

3.9.4.1 Terminals not being tested - Inputs to low voltage instrumentation and control equipment shall be grounded during impulse tests.

3.9.5 Electromagnetic compatibility - The unit shall be designed to minimize the generation of electromagnetic interference. Enclosed case construction shall provide continuity of electrical shielding with a low radio frequency impedance path to ground and across all mechanical discontinuities. Conducted and radiated interference produced outside its physical envelope by the operation of the unit shall not exceed the requirements of Specification MIL-STD-461.

3.10 Life - The unit shall be so designed that when operating under any temperature or altitude condition indicated by the detail specification, the useful life of the unit shall be at least 100 hours operating full load, in a period of 5 years.

3.11 Reliability - The requirements of MIL-STD-785 shall apply. Reliability shall be considered as a design factor on an equal basis with performance, weight, etc. Based upon a best available knowledge of component reliability characteristics, the design safety factors used, and the operating conditions specified herein, the mean-time-between-failure of each major system component shall be calculated and this information shall be presented with the vendor's design proposal.

3.11.1 Reliability plan - The vendor shall submit with the design proposal the following data:

a. Description of the reliability organization, and of the system used to collect and analyze data.

b. Methods of analyzing field data and implementation of corrective action when the products do not live up to expectations.

c. A plan to accumulate and evaluate failure data during the production run on the hardware.

d. Program plan for scheduling corrective action for failures detected in the production hardware.

e. Preliminary reliability assessment of the system. This presentation shall include failure mode and effects analysis of the major functions of the equipment.

f. Overall program plan encompassing the development, production and post-production phases.

g. Schedule for updating the expected reliability type reports such as failure modes and effects analysis, etc.

3.12 Safety - The vendor shall conduct an active system safety program during the design and development of the electrical power source system. The system safety program shall have the primary objectives of (1) identification, (2) evaluation, and (3) resolution of hazardous events within the electrical power system. Hazardous events are defined, in the system safety context, as those fault modes, special circumstances, etc., which result in injury to personnel or damage to equipment.

3.12.1 Safety analysis - The vendor shall conduct a preliminary safety analysis to identify and evaluate the hazardous events which may occur in operation and maintenance.

3.12.2 Hazard resolution - Hazardous events shall be resolved by design in accordance with MIL-STD-882; Appendix A shall apply for MHD generator.

3.12.3 Safety documentation - A preliminary safety analysis shall be provided with the proposal and periodically updated at least semiannually for the life of the contract.

3.13 Maintainability - The requirements of MIL-STD-470, MIL-STD-471, and MIL-STD-472 shall apply. Maintainability shall be considered a parameter in the design of the equipment. The design shall provide for rapid accomplishment of inspections, operational testing, malfunction detection and isolation, removal, installation and shop repair with a minimum expenditure of time, skill and test equipment.

3.14 Marking - Power sources shall be marked with the military part number, manufacturer's part number, manufacturer's code symbol, terminal identification (circuit diagram where space permits) and date code and lot symbols in accordance with method I, MIL-STD-1285. Markings shall remain legible after all tests. Key markings of a classified nature shall not be included.

3.15 Safety wiring and staking - Accidental loosening of screws and screw parts and other connections shall be prevented by safety wiring (0.032 inch minimum outside diameter) where practicable, by staking, or other approved methods.

3.16 Workmanship - All machined surfaces shall have a smooth finish and all details of manufacture, including the preparation of parts and accessories, shall be in accordance with the best practice for high quality electrical equipment. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts, plating, lacquering, riveting, clearance between soldered connections, and ruggedness.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Test equipment and inspection facilities - Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection shall be established and maintained by the inspection facility. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-C-45662.

4.2 Classification of inspection - The inspections specified herein are classified as follows:

a. Materials inspection (see 4.3).
b. Qualification inspection (see 4.5).
c. Quality conformance inspection (see 4.6).

4.3 Materials inspection - Materials inspection shall consist of certification supported by verifying data that the materials listed in table G1 used in fabricating the power source, are in accordance with the applicable referenced specifications or requirements prior to such fabrication.

4.4 Inspection conditions - Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202, MIL-STD-454 and MIL-E-5400.

TABLE G1. Materials Inspection

MATERIALS	REQUIREMENT PARAGRAPH	APPLICABLE SPECIFICATION
Insulating material:		
Laminated phenolic	3.3.2.1	MIL-P-997, L-P-513, MIL-P-15037, or MIL-P-15047
Molded phenolic or melamine -	3.3.2.2	MIL-M-14
Ceramic (external use) -	3.3.2.3	MIL-I-10
Laminated Plastic Sheet -	3.3.2.4	MIL-P-18177
Coolants	3.3.2.5.1	MIL-L-7818
Insulating gases	3.3.2.6	BB-S-1419
Dissimilar Metals	3.3.3.4	MS 33586
Solder and solder flux	3.3.3.5	QQ-S-571 or MIL-F-14256
Wire:		
Insulated wire	3.3.8.1	MIL-W-76, MIL-W-16878, or MIL-W-81381
Wire supports	3.3.8.2	High Voltage Cable Assembly Criteria
Fastener	3.3.10	MIL-F-5591

4.4.1 Test frequency - When an ac power source frequency is specified herein, the frequency shall be within ±2 percent of the nominal value. The test frequency shall be the geometric mean of the specified frequency range or a lower value selected by the manufacturer.

4.4.2 Test voltage - When the rated input voltages are specified with a tolerance (see 3.1), the test voltage shall be the rated voltage (e.g., 5,000 ± 100 volts shall be tested at 5,000 volts). For dielectric withstanding voltage tests, the peak of the voltage applied shall not exceed by more than 5 percent the peak of the pure sine voltage.

4.5 Qualification inspection - Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on a sample unit produced with equipment and procedures normally used in production.

4.5.1 Sample size - A sample of one unit shall be comprised of a power source and shall be submitted for inspection.

4.5.2 Inspection routine - The sample unit shall be subjected to the inspections specified in Table G2 in the order shown.

4.5.3 Failure - One or more failures of the specified qualification inspection tests listed in Table G2 shall be cause for refusal to grant qualification approval.

4.5.4 Test reports - Samples shall be accompanied with certified test reports in accordance with MIL-STD-831, including a statement that the samples have been subjected to the tests and comply with this specification. Photographs of oscilloscope or instrument displays of ripple voltage shall be submitted (see 4.8.2.1). Samples shall also be accompanied with two copies of outline and detail assembly drawings thereof and two copies of sample instructions with illustrations and diagrams, if necessary, covering the installation of the power source.

Table G2. Qualification Inspection

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Visual and mechanical examination	3.1, 3.3.1.3, 3.3.1.4, 3.3.3.6, 3.3.3.7, 3.4.3, 3.4.3.15, 3.4.3.18.1, 3.4.3.18.2, 3.4.3.19, 3.4.3.19.1, 3.4.3.19.2, 3.4.3.20, 3.4.3.22, 3.4.4.3, 3.7.1 through 3.7.7., 3.8.1 through 3.8.4, 3.8.7, 3.8.10 and 3.11 through 3.16	
Gas filled units	3.3.2.6.1	4.12.1.2
Pressure vacuum transducer	3.3.2.6.2	4.12.2
Liquid temperature transducer	3.3.2.6.3	4.12.2
Pressure-vacuum bleeder	3.3.2.6.4	4.12.2.2
Tanks	3.3.2.6.5	4.12.3
Fans, pumps, and control	3.3.2.6.6	4.12.2.3
ALTERNATING CURRENT GENERATOR		
Speed range	3.4.3.1	4.9.2
Load	3.4.3.2	4.9.1
Continuous load	3.4.3.2.1	4.9.1
Overload	3.4.3.2.2	4.9.3
Short Circuit	3.4.3.2.3	4.9.4
Symmetry of construction	3.4.3.3	4.9.5
Efficiency	3.4.3.4	4.9.5
Useful life	3.4.3.5.1	4.9.6
Transient voltage characteristics	3.4.3.6	4.9.4
Voltage buildup	3.4.3.7	4.9.1
Voltage recovery time	3.4.3.8	4.9.2
Voltage regulation	3.4.3.9	4.9.1,4.9.2
Starting performance	3.4.3.11	4.9.7
Exciter	3.4.3.12	4.9.1,4.9.2
Generator field control and indication	3.4.3.14.1	4.9.1
Anti-cycling and lockout control	3.4.3.14.2	4.9.8
Power ready control	3.4.3.14.3	4.9.1
Underspeed trip circuit	3.4.3.14.4	4.9.1,4.9.2
Overspeed/underspeed	3.4.3.14.5	4.9.1,4.9.2
Charge pressure switch	3.4.3.14.6	4.12.2
Oil, gas and other coolant filtration	3.4.3.16.1	4.12.2

Table G2. Qualification Inspection (Cont'd)

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Seals	3.4.3.16.2	4.12.1
Reservoir	3.4.3.16.3	4.12.3
Helium	3.4.3.17	4.9.9
Detectors	3.4.3.17.1	4.9.9.1
Voltage regulator	3.4.4.4	4.9.10
Useful life	3.4.4.4.6	4.9.6
MAGNETOHYDRODYNAMIC GENERATOR		
Continuous load	3.5.3.1.1	4.10.1
Overload	3.4.3.1.2	4.10.2
Short circuit and open circuit	3.5.3.1.3	4.10.3
Efficiency	3.5.3.2	4.10.4
Useful life	3.5.3.3.1	4.10.5
Voltage requirement	3.5.3.4	4.10.1
Voltage	3.5.3.4.1	4.10.1
Voltage recovery time	3.5.3.4.2	4.10.2
Transient voltage characteristics	3.5.3.4.3	4.10.2
Starting performance	3.5.3.5	4.10.1
Magnet	3.5.3.6	4.10.6
Seals	3.5.3.6.2	4.12.1
Exhaust gas	3.5.3.6.3	4.10.1
Magnet start and stop	3.5.3.6.4	4.10.6
Shielding	3.5.3.6.5	4.13.5
Retention of magnetism	3.5.3.6.6	4.10.6
Tankage and storage	3.5.3.7	4.12.3
Pressure-vacuum bleeder	3.5.3.7.2	4.12.2.2
Monitor	3.5.3.7.3	4.10.1
Cooling air	3.5.3.8	4.10.1
MHD system control	3.5.4.1.1	4.10.1
Magnetic field protection	3.5.4.1.2	4.10.1
Fault isolation control	3.5.4.1.3	4.10.2
Power ready control	3.5.4.1.4	4.10.1
Cooling	3.5.5	4.10.1
Helium	3.5.6	4.9.9
MHD processing and control unit	3.5.7	4.10.1
Monitor and display unit	3.5.8	4.10.1
Exhaust gases	3.5.9	4.10.1
ENVIRONMENTAL TESTS		
Temperature and altitude	3.6.1	4.11.1,4.11.2
Humidity	3.6.2	4.11.3
Sand and dust	3.6.3	4.11.4
Salt spray	3.6.4	4.11.5

Table G2. Qualification Inspection (Cont'd)

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Fungus	3.6.5	4.11.6
Shock	3.6.6	4.11.7
Vibration airplane	3.6.7.1	4.11.8
generator	3.6.7.2	4.11.8.3
Flammability	3.6.8	4.11.9
Nuclear radiation	3.6.9	4.11.10
ELECTRICAL		
Bushings	3.8.3.4	4.12.6
Solderability	3.8.5	4.12.7
Resistance to soldering heat	3.8.6	4.12.8
Grounding	3.8.8	4.12.9
Surge arrestors	3.8.9	4.12.10
HIGH VOLTAGE		
Insulation resistance	3.9.1	4.13.1
Dielectric withstanding voltage	3.9.2	4.13.2
Partial discharges	3.9.3	4.13.3
Impulse	3.9.4	4.13.4
Electromagnetic compatibility	3.9.5	4.13.5

4.5.5 Rejection and retest of qualification and quality conformance units - Units which have been rejected or returned to the manufacturer for any reason during qualification or quality conformance tests may be reworked or have parts replaced to correct defects. Before resubmitting the unit, full particulars concerning the rejection and corrective action taken by the manufacturer must be submitted in writing by the manufacturer to the test activity and to the procuring activity. Tests shall not be resumed until such a report is received. Where qualification tests are conducted under the auspices of the manufacturer, the procuring activity shall be advised upon failure of a qualification sample and of the action taken by the manufacturer with regard to the failure.

4.5.6 Retention of qualification - To retain qualification, the supplier shall meet the requirements of 4.5.2 every 36 months. The qualifying activity shall be notified in advance before action is initiated for retention of qualification. The supplier shall also forward at 12-month intervals to the qualifying activity a summary of the results of the tests performed for inspection of product for delivery, groups A and B, indicating as a minimum the number of lots that have passed and the number that failed. The results of tests of all rework lots shall be identified and accounted for. Group A products shall be for alternating current generators; group B products shall be for MHD generators.

4.6 Quality conformance inspection

4.6.1 Inspection of product for delivery - Inspection of the product for delivery shall consist of the inspections and tests specified in Table G3. All deliverable high voltage, high power - power sources shall be subjected to the inspections specified in Table G3.

Table G3. Quality Conformance Inspection

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Visual and mechanical examination	3.1, 3.3.2.6.1 through 3.3.2.6.6, 3.4.3.15 through 3.4.3.21, 3.4.4.2 through 3.4.4.4.6, 3.5.3.6 through 3.5.7, 3.5.9, 3.7 through 3.7.7, 3.8 through 3.8.10, 3.11 through 3.17	
ALTERNATING CURRENT GENERATOR		
Load	3.4.3.2	4.9.1
Short circuit and open circuit	3.4.3.2.3	4.9.4
Efficiency	3.4.3.4	4.9.5
Voltage	3.4.3.7	4.9.1
Seals	3.4.3.16.2	4.12.1
Helium	3.4.3.17	4.9.9
MAGNETOHYDRODYNAMIC GENERATOR		
Continuous load	3.5.3.1.1	4.10.1
Short circuit	3.5.3.1.3	4.10.3
Efficiency	3.5.3.2	4.10.4
Voltage buildup	3.5.3.4.1	4.10.1
Seals	3.5.3.6.2	4.12.1
Monitor and display unit	3.5.7	4.10.1
HIGH VOLTAGE TESTS		
Insulation resistance	3.9.1	4.13.1
Dielectric withstanding voltage	3.9.2	4.13.2
Partial discharges	3.9.3	4.13.3
Electromagnetic compatibility	3.9.5	4.13.5

4.6.1.1 Inspection lot - Inspection shall be for a completely assembled power source of the same family, type, and class having similar electrical characteristics, manufactured under essentially the same conditions, and having similar construction and materials. (Similar construction and materials shall be construed to include differences that will not affect test results.)

4.6.1.2 Rejected lots - If an inspection article is rejected, the supplier may rework it to correct the defects, or screen out the defective components and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such articles shall be separate from new articles and shall be clearly identified as reinspected articles.

4.6.1.3 Disposition of units - Units which have passed inspection may be delivered on the contract or purchase order, only if the units are accepted and are still within specified electrical tolerances, and if the terminals of the sample units are clean and smooth.

4.6.2 Inspection of preparation for delivery - The inspection of the preservation-packaging and interior package marking shall be in accordance with the quality conformance inspection requirements of MIL-P-116. The inspection of the packing and marking for shipment and storage shall be in accordance with the quality assurance provisions of the applicable container specification and the marking requirements of MIL-STD-129.

4.7 Methods of examination and test

4.7.1 Visual and mechanical examination - Visual and mechanical examinations shall apply to group A and group B power sources.

4.7.1.1 External - The power source shall be examined to verify that the materials, external design and construction, physical dimensions, weight, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.2, 3.3, 3.4.3.22, 3.5.3, 3.7 through 3.7.7, 3.8 through 3.8.10, 3.14, 3.15 and 3.16).

4.7.1.2 Internal - The internal parts of the power source shall be examined to verify that the materials, internal design and construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.3.2 through 3.3.8.2, 3.3.10 through 3.3.10.3, 3.4.3.14 through 3.4.3.22, 3.5.3.6.2, 3.5.3.7, 3.5.4 through 3.5.8, 3.7, 3.8 through 3.8.7, 3.8.9, 3.8.10, 3.14, 3.15 and 3.16). Internal design, construction, and workmanship will include inspection for:

a. Dirt and debris.
b. Loose ends on wire bundling lacing and ties.
c. Rough surfaces on corona shields.
d. Correct spacing of high voltage wiring.
e. Burns, scratches, foreign deposits, and delamination of insulating boards.
f. Grease, oil, or water leaks.
g. Seals
h. Cooling-ducts and tubing
i. Cryogenic line and auxiliary coupling mechanisms
j. Overboard venting apparatus
k. Sensors and monitor connections and installation

4.7.1.3 Post-test - Power sources shall be examined to verify that the protective coating, filling material, and case construction are in accordance with the applicable requirements (see 4.3).

4.8 Electrical performance test conditions

4.8.1 Altitude and temperature - The steady state output characteristics tests shall be conducted at an ambient temperature of $20^{o}C \pm 10^{o}C$ and an ambient altitude of -1000 feet to +5000 feet.

4.8.2 Instrumentation - All instruments used to measure time, voltage, and current shall have an accuracy of 1 percent or less. Instruments shall have been calibrated within 30 days of the date on which the tests described in paragraphs 4.8 are conducted unless the instrument history records provide

sufficient evidence to support longer periods between calibration. All meter indications shall be equal to or within the tolerance range specified within this drawing.

4.8.3 Electrical measurements - Steady state electrical measurements of volts, amperes, ohms, and watts shall be made with laboratory type instruments having an accuracy of 0.75 percent of full scale.

All photographs of oscilloscope traces shall show the sweep time, vertical deflection sensitivity, rise time of the scope, and amplifier, where applicable, and frequency response at the 3 db point.

All oscillograph recordings shall show a calibration trace, and the calculated values of instantaneous voltage, current, and power from the recordings shall be accurate to ±5 percent. The frequency response of all recording instruments and oscillographs used in the tests shall be included in the test data.

Measurements of frequency shall have an accuracy of ±1 Hz.

4.8.4 *Temperature measurements* - The accuracy of the temperature measurements shall be ±2°C.

4.9 Alternating current generator electrical performance - The ability of the unit to deliver rated power at rated speed for a period of 5 minutes shall be demonstrated. The generator shall be properly mounted to a prime mover qualified to bring the generator from standstill to full speed and full load in one second. The prime mover and generator shall be subjected to the electrical, mechanical and environmental tests required by the specification and listed in table G2.

4.9.1 Continuous load - The power source assembly shall be started, brought to full 1.0 ± 0.05 P.U. rpm and 1.0 P.U. MW and operated for five minutes. During this test the following parameters shall be monitored:

a. Coolant inlet and outlet temperature
b. Room ambient air temperature
c. Cryogenic helium consumption
d. Cryogenic temperature (includes cooling time)
e. Machine critical hot-spot temperature
f. Phase-to-neutral and line-to-line voltages and currents
g. Power output
h. Fuel consumption
i. Exciter output voltage and current
j. Control relay operation
k. Sensor inputs to the monitor
l. Display
m. Helium gas ducting system
n. Helium leakage

Time to cool cryogenic components to operating temperature shall be recorded. Quantity of helium used shall be measured and recorded. During the start up and stopping period, the operation of the power ready control, underspeed/overspeed protection, generator field control, and frequency controls shall be monitored for proper function. The generator field control shall be monitored by monitoring generator output modulation.

4.9.2 Speed range - The generator shall be brought up to speed in one second and stabilized at 1.0 $\pm$ 0.05 PU rpm for 10 seconds with 1.0 $\pm$ 0.05 PU MW output from the generator. The prime mover speed control shall be adjusted to operate from 1.0 $\pm$ 0.05 PU rpm to 1.15 $\pm$ 0.05 PU rpm to 0.9 $\pm$ 0.05 PU rpm to 1.0 $\pm$ 0.05 PU rpm in 2 minutes time. The exciter and control system shall hold the output at 1.0 $\pm$ 0.05 MW during this test. The overspeed/underspeed frequency control relays shall be adjusted to accept this speed range without shutting off the prime mover or generator output.

4.9.3 Overload - The power source assembly shall be brought to 1.0 $\pm$ 0.05 PU rpm and 1.0 $\pm$ 0.05 PU MW in one second. The system load shall be changed to accept 1.25 PU MW load for 10 seconds and 1.5 PU MW load for 1 second at

which time the unit load shall be reduced to full load for 10 seconds and turned off. Measured parameters shall include:

a. An oscillograph or a magnetic tape reproduction of the monitor output of generator voltage, current, speed, power voltage modulation. Likewise recordings of the exciter and control system shall be made.

b. Parameters a through n of paragraph 4.9.1 shall be recorded.

4.9.4 Short circuit - the power source assembly shall be brought to 1.0 ± 0.05 PU rpm and 1.0 ± 0.05 PU MW output in one second and stabilized at full load for 10 seconds. A short circuit shall be applied to the output. The fault isolation control shall operate to limit the fault current to less than 1.5 PU MW and the control unit shall ramp the exciter toward zero output. No damage or overstress shall be caused by this test. Measured parameters shall include items a through n of paragraph 4.9.1. Permanent recordings of the generator, exciter and fault isolation control relay shall be made during this test. Phase output voltages shall be within ± 0.2 PU volts of nominal output voltage during the fault.

4.9.5 Efficiency and symmetry of construction - The system electrical efficiency and the generator symmetry of construction shall be calculated from the data of paragraph 4.9.1.

4.9.6 Useful life - Useful life shall be verified by test. The qualification model shall be operated at 1.0 ± 0.05 PU MW at 1.0 ± 0.05 PU rpm for 2.5 minutes per hour for 30 days for a total of 30 hours operation. During this test,control adjustments and resupply of fuel and coolants are permitted.

Each machine built to the same specification and drawings as the qualification model shall be tested for 10 cycles of 2.5 minutes per hour at full load and normal operating speed; i.e., 1.0 ± 0.05 PU MW and 1.0 ± 0.05 PU rpm.

4.9.7 Temperature (see 3.4.3.12) - The test of paragraph 4.11.1 shall apply. Temperature shall be stabilized to the extent that all required heaters and non-heated parts are thermally stabilized internally and externally. The test shall be complete after the machine has successfully passed 10 cycles of 2.5 minutes per hour in one 24 hour period. This test may be considered part of the useful life test of paragraph 4.9.6.

4.9.8 Anticycling control - The control system shall be operated in a manner to simulate faults (power outages) of the airplane power system, the emergency power system, and the generator output. The anticycling and lockout control relay shall operate to properly keep continuous power to the other control relays.

4.9.9 Helium - Helium shall be of technical grade as defined in Federal Specification BB-H-1168. Dewar, lines, and filters shall be free of lint, dirt and foreign materials such as water and gases. Tanks and equipment shall be evacuated as specified in 4.12.3.2.

4.9.9.1 Helium detector - Helium detectors installed in the power supply assembly and the assembly area shall be tested at least three times during qualification. No damage to the equipment or sensor shall result from these tests.

4.9.10 Voltage regulator - The voltage regulator shall be tested as part of the power source assembly. The exciter shall meet all the requirements of paragraph 4.9.1 through 4.9.7.

4.10 Magnetohydrodynamic generator electrical performance - The ability of the unit to deliver rated power for 5 minutes shall be demonstrated. The generator shall be properly mounted on a test platform with all ancillary equipment attached, including regulator coolant loops, fuel and coolant supplies, monitor and control, displays and test instrumentation.

4.10.1 Load - The MHD generator assembly shall be started, brought to full load 1.0 ± 0.05 PU MW in one second, and operated for five minutes. The following parameters shall be measured and monitored during the test:

a. Room ambient air temperature
b. Coolant inlet and outlet temperature
c. Cryogenic helium consumption
d. Helium temperature inlet and exhaust
e. MHD channel temperatures
f. Fuel consumption - fuel and seed
g. Helium gas ducting system
h. Helium leak detector
i. Exhaust temperature
j. Exhaust signature
k. Power output
l. Voltage
m. Control relay operation
n. Sensor operation to the processor and monitor subassemblies
o. Display
p. Monitor

Time and quantity of helium to cool the cryogenic subassemblies shall be recorded. The operation of all control relays shall be observed and monitored for proper function during the test.

After five minutes operation the MHD generator shall be shut down. Oscillograph or magnetic tape reproduction of the monitor inputs and outputs shall be obtained during start and stop. Included shall be voltage, current, power, and voltage modulation for the 5 minute run.

4.10.2 Overload - The MHD generator assembly shall be brought up to full power output in one second. The measurements and load applications of paragraph 4.9.3 shall apply.

4.10.3 Short circuit - The MHD generator assembly shall be brought up to 1.0 ±0.05 PU MW in one second and stabilized for 10 seconds. A short circuit shall be applied to the output terminals. The fault isolation control shall operate and shut down the generator by limiting the current to less than 1.5 PU amperes. No damage or overstress shall be caused by the short circuit to any subassembly or part. Measured parameters shall include items a through p of 4.10.1. Oscillograph and/or magnetic tape reproduction of the start through complete stopping of the equipment shall be made during the test.

4.10.4 Efficiency - MHD generator assembly efficiency shall be calculated from the data obtained during the load test, 4.10.1.

4.10.5 Useful life - Useful life shall be verified by test. The qualification assembly shall be subjected to 2.5 minutes per hour at full load (1.0 ±0.05 PU MW) for 30 days (24 hours per day). During this test, control adjustment and resupply of coolants and fuels is permitted. Parts and subassembly changes are cause for failure.

Each production model built to the same specification and drawings or the qualification model shall be tested for 20 hours at 2.5 minutes per hour, at full load, as an acceptance test.

4.10.6 Magnet - The magnet, magnet control circuit, and helium coolant subsystem for the MHD generator assembly shall meet the performance requirements of paragraphs 3.5.3.1 through 3.5.3.5. The magnet shield shall be sufficient for the MHD generator assembly to meet the performance of 4.13.5.

The magnet inputs and outputs shall be determined at the beginning and end of the life test. No perceptible degradation of magnetic properties shall be noted.

4.11 Environmental tests

4.11.1 Thermal shock (see 3.4.3.1) - The test article shall be tested in accordance with method 107 of MIL-STD-202. The temperature for step 3 shall be the maximum operating temperature for the class. The following details and exceptions shall apply:

a. Test condition - A, 20 hours, for qualification

b. After cycling - The test article shall be examined for evidence of leakage and other visible damage.

4.11.2 Altitude - Altitude tests are not required for hermetically sealed pressurized subassemblies. Parts such as cables and connectors on sealed or pressurized units, and unpressurized, unsealed units which are designed for operation above 10,000 feet altitude shall be tested in accordance with method 105 of MIL-STD-202. The test articles shall operate at normal voltage at the altitude specified in the detailed specification. The power supply assembly will not be tested in an altitude chamber. All subassemblies with open cases (unpressurized) with operating voltages greater than 150 volts, peak shall be altitude tested.

4.11.3 Humidity - The unit shall be subjected to the humidity test, Method 103B, of Specification MIL-STD-202. Immediately following this test the unit shall pass the full load test of either 4.9.1 or 4.10.1 as applicable at nominal input conditions and ambient temperature.

4.11.4 Sand and dust - This test is not applicable for hermetically sealed or pressurized subassemblies. Unpressurized or unsealed units shall be tested in accordance with method 110A, or MIL-STD-202. The test articles shall be non-operating during the test.

4.11.5 Salt spray (corrosion). When specified (see 3.2) - The test article shall be tested in accordance with method 101 of MIL-STD-202.

a. Test condition - B.

b. Salt solution concentration - 5 percent.

c. Examination after exposure - The test article shall be thoroughly washed. The temperature shall not exceed 38°C. The test article shall be placed in an oven maintained at 50°C $\pm$ 3°C for a period of 24 $\pm$ 4 hours. At the end of this period, the test article shall be removed from the oven and examined for corrosion.

4.11.6 Fungus - Unless certification is provided, the test article shall be tested in accordance with method 508 of MIL-STD-810 (see 3.2).

4.11.7 Shock - The test article shall be tested in accordance with 4.11.7.1, or when specified (see 3.2), in accordance with 4.11.7.2.

4.11.7.1 Specified pulse - The test article shall be tested in accordance with method 213 of MIL-STD-202. The following details and exceptions shall apply:

a. Test condition - I, unless otherwise specified.

b. Examinations after shock - The test article shall be examined for evidence of leakage and physical damage.

4.11.7.2 High-impact - The test article shall be tested in accordance with method 207 of MIL-STD-202. The following detail and exception shall apply:

a. Mounting fixtures - Figure "Standard mounting fixtures for electrical controller parts" of method 207.

b. Examinations after shock - As specified in 4.11.7.1(b).

4.11.8 Vibration - The test article shall be tested in accordance with 4.11.8.1 or 4.11.8.2, as applicable.

4.11.8.1 <u>Vibration, low frequency</u> - The test article shall be tested in accordance with method 201 of MIL-STD-202. The following details and exceptions shall apply:

a. Test and measurements prior to vibrating - Not applicable.

b. Method of mounting - The test article shall be rigidly mounted by its normal mounting means.

c. Procedure - When specified (see 3.2) the test article shall be placed in a test chamber and preheated to the specified maximum ambient temperature for the class (see 3.2) plus one-half the allowable temperature rise. Vibration in each plane shall begin 5 minutes after removal from the test chamber.

d. Apparatus - The sequence of vibration shall be as follows: First vertically, and then horizontally in two mutually perpendicular directions. Two machines may be used (one vibrating horizontally and one vibrating vertically), or a single machine may be used which provides for both vertical and horizontal table motion, or a vertical vibrating machine, at the option of the supplier.

e. Examinations after vibration - The test article shall be examined for evidence of leakage and physical damage.

4.11.8.2 <u>Vibration, high frequency (when specified -see 3.2)</u>- The test article shall be tested in accordance with method 204 of MIL-STD-202. The following details and exception shall apply:

a. Mounting of specimens - As specified in 4.11.8.1(b).

b. Test-condition - D, unless otherwise specified.

c. Airplane vibration magnitudes defined in the detailed specification shall apply (see 3.2).

d. Examinations after vibration - As specified in 4.11.8.1(e).

4.11.8.3 Assembly vibration - The test assembly shall not exceed the vibration limits defined in the detailed specification, when operated at full load for five minutes.

4.11.9 Flammability (grade 5) - The test article shall be tested in accordance with method 111 of MIL-STD-202. The following details and exception shall apply:

a. Point of impingement of applied flame - One of the lower free corners, so that the flame is just in contact with the test article. The free corners of the test article are those corners which are the greatest distance from the mounting brackets. However, the flame shall be applied so that it will impinge upon the corner or area containing the encapsulating compound.

b. Allowable time for burning of visible flame on specimen - 3 minutes maximum.

c. Examinations during and after test - The test article shall be examined for evidence of violent burning which results in an explosive-type fire, dripping of flaming material, and visible burning which continues beyond the allowable duration after removal of the applied flame.

4.11.10 Nuclear radiation - When specified by the detail specification, a nuclear radiation exposure test shall be conducted in accordance with Standard MIL-STD-446. When required, the unit shall pass the full load test of 4.8.2 after completion of the radiation exposure.

4.12 Mechanical and electrical tests

4.12.1 Seal - The test article shall be tested in accordance with 4.12.1.1, 4.12.1.2, or 4.12.1.3, as applicable. Any unit or subassembly which shows evidence of leakage may be given remedial treatment. After completion of the treatment, the seal test shall be repeated as evidence that such remedial treatment is adequate. All other units in the lot which have been given similar satisfactory remedial treatment shall be acceptable.

4.12.1.1 Liquid-filled units - The test article shall be heated in an oven maintained at a temperature equal to or not more than 5°C greater than the sum of the specified maximum ambient temperature and the allowable temperature rise (see 3.2), for not less than 6 hours.

4.12.1.2 Gas-filled units - The test article shall be tested in accordance with method 112 of MIL-STD-202. The following details shall apply:

a. Test condition - C.

b. Leakage-rate sensitivity - 10^{-3} Pascal-cubic centimeter/second.

c. Procedure IV, as specified (see 3.1 and 6.1.2), test for gross leaks as specified in 4.12.2.

4.12.2 Auxiliary components - Auxiliary components include pressure and temperature transducers and switches, fans, pumps, and controls. These units shall be tested at least three times during qualification. No damage to the test assembly or device shall result from these tests.

4.12.2.1 Transducers - Pressure-vacuum transducer and liquid temperature transducers shall be tested at least three times during qualification. No damage to the test assembly or sensor shall result from these tests.

4.12.2.2 Pressure vacuum bleeder - The pressure vacuum bleeder valve shall be tested at least three times during qualification. No damage to the test assembly or sensors shall result from these tests.

4.12.2.3 Motors - Fan, pump, and control motors shall be tested for electrical continuity. Fan and pump motors shall function, without failure, during the life test.

4.12.3 Tank design proof pressure - Proof pressure cycle tests shall be conducted in accordance with MIL-STD-1540. The temperature of the test shall be stabilized and maintained at a temperature of 71°C throughout the test.

As an alternative, the test may be conducted at room temperature if the test pressure is suitably adjusted to account for temperature effects on strength and fracture toughness.

Proof pressure cycles shall consist of raising the tank piping, fittings or hose internal pressure to 1.5 times the maximum operating pressure specified in the detailed specification, maintaining this pressure for 5 minutes and then decreasing the pressure to 0 psig. There shall be no evidence of leakage during the test.

The following test cycle shall be performed:

Test	Cycle
Acceptance	1
Qualification	3

At the conclusion of the test there shall be no evidence of yielding of the tank material. The volumetric change shall be determined and recorded. Permanent volumetric change shall not exceed 0.2%.

4.12.3.1 Tank design, burst - Design burst pressure test shall be conducted in accordance with MIL-STD-1540. The temperature of the test shall be stabilized and maintained at a temperature of 71^{o}C throughout the test.

As an alternative, the test may be conducted at room temperature if the pressure is suitably adjusted to account for temperature effects on strength and fracture toughness.

Burst pressure tests shall consist of raising the tank pressure to 4 times the maximum operating pressure specified in the detailed specification and maintaining this pressure to verify that the design burst pressure is met or exceeded. The internal pressure shall be applied at a uniform rate such that stresses are not imposed due to shock loading.

4.12.3.2 Internal vacuum - The tank shall be evacuated to an absolute pressure of 100 pascals, maximum, internal pressure for 15-minutes duration while exposed to ambient pressure externally. No permanent deformation shall be sustained.

4.12.4 Cooling - This test shall be performed during the steady state conformance operating time tests of paragraph 4.9.1 or 4.10 as applicable. The test shall be performed with coolant temperatures and equipment temperatures stabilized at ambient temperature of 23 $\pm$ 5^{o}C. During the test, coolant inlet and outlet temperatures shall be recorded for test and standby conditions. Coolant system efficiency shall be determined for each stage of the test. Data on heat rejection (defined as the difference between input and output power expressed in kilowatts) shall be furnished for the above tests. The power source shall conform to the specified requirements of paragraph 3.4.3.16 or 3.5.5.

The coolant system shall be tested in accordance with paragraphs 4.12.3 and 4.12.3.1. There shall be no evidence of leakage during the test.

4.12.5 Terminal strength - The article subassemblies shall be tested as specified in 4.12.5.1 through 4.12.5.2.2 inclusive, as applicable. After each test, the terminals shall be examined for loosening and rupturing and other mechanical damage. Unless otherwise specified, all terminals on each test sample shall be subjected to the following tests, up to a maximum of four identical terminals per sample.

4.12.5.1 Pull

4.12.5.1.1 Solid-wire and insulated wire lead terminals - The test article subassemblies and auxiliary components, such as sensors and motors, shall be tested in accordance with Method 211 of MIL-STD-202. The following details shall apply:

a. Test condition - A.
b. Points of measurement - A force shall be applied in the direction of the axis of termination and shall be increased gradually until the magnitude specified in table IV is reached and shall be maintained for a period of 5 to 10 seconds.

4.12.5.1.2 Solder terminals - Auxiliary components shall be tested in accordance with Method 211 of MIL-STD-202. The following details shall apply:

a. Test condition - A.
b. Points of measurement - A force as specified in table G4 shall be applied to each terminal at the point where the lead from the external circuit connects to it. The force shall be applied in the weakest direction of the terminal and shall be increased gradually to the specified magnitude and shall be maintained at that value for a period of 5 to 10 seconds.

TABLE G4. Pull.

Cross-sectional area of electrode at its smallest point at which lead from external circuit connects	Force
Circular mils	Pounds
$\leq$ 2,000 ----------------------------------	2.0
$>$ 2,000 ----------------------------------	5.0

4.12.5.2 Twist or bend

4.12.5.2.1 Solid-wire lead terminals (other than printed circuit terminals) - Following the test specified in 4.12.5.1.1, the article subassembly terminals shall be tested in accordance with Method 211 of MIL-STD-202. The following detail and exception shall apply:

a. Test condition - D.

b. Application of torsion - The body of the component part or the clamped terminal shall be rotated through 360 degrees about the original axis of the bent terminal, in alternating directions, for a total of five rotations, at the rate of approximately 3 seconds per rotation.

4.12.5.2.2 Flat solder terminals - Any terminal that shows permanent deformation greater than 15 degrees of the metal portion of the terminal in the terminal-pull test specified in 4.12.5.1.2 shall be tested in accordance with Method 211 of MIL-STD-202. This test does not apply to terminals which show permanent deformation but are not designed to be bent 45 degrees. The following detail and exception shall apply:

a. Test condition - B.

b. Number of bending operations - Five times through an angle of 90 degrees (45 degrees each side of center).

4.12.6 Bushings - The basic insulation level (impulse test) of bushings shall be twice rated voltage. Bushings shall be given dielectric withstanding voltage tests of 1.6 times rated voltage.

4.12.7 Solderability - Solder connections for the power source shall be tested in accordance with 4.12.7.1 or 4.12.7.2, as applicable. The method in 4.12.7.1 is preferred and shall be specified whenever practicable, otherwise the method in 4.12.7.2 shall be used.

4.12.7.1 Solder bath method - Solder connections shall be tested in accordance with Method 208 of MIL-STD-202. The following details shall apply:

a. Special preparation of specimen-Sample components shall not have been soldered during any of the previous tests.
b. Number of terminations of each part to be tested - A minimum of two of each type of terminal.

4.12.7.2 Soldering iron method - The test shall be performed on solder terminations, attached to the power source parts. The solder shall conform to type S, composition Sn60, of QQ-S-571. The flux shall conform to type A or W, as applicable, of MIL-F-14256. The temperature of the bit shall be 300° - 350°C. The iron and solder shall be applied to the termination for 10 seconds. The solder shall be applied for the first 2 seconds. Tinning, as evidenced by the free flowing of the solder with proper wetting of the termination, shall be completed within the first two seconds. The part under test shall remain under standard atmospheric conditions for recovery for fifteen minutes, before final measurements are made.

a. Special preparation of specimen - The surface shall be smooth and properly tinned and the solder terminations shall not have been soldered during any previous test.
b. Number of terminations - in accordance with 4.12.7.1.
c. Examinations of terminations - in accordance with Method 208 of MIL-STD-202.

d. Soldering irons - The soldering iron shall have one of the following bit sizes:

(1) 0.3 inch diameter, 1.25 inch exposed length reduced to a wedge shape, over a length of approximately 0.4 inch.

(2) 0.125 inch diameter, 0.5 inch exposed length, reduced to a wedge shape, over a length of approximately 0.2 inch.

e. Point of application of soldering iron - 1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal, whichever point is closer to the insulating material.

4.12.8 Resistance to soldering heat - Power source parts shall be tested in accordance with 4.12.8.1 or 4.12.8.2, as applicable. The method in 4.12.8.1 is preferred and specified whenever practical, otherwise the method in 4.12.8.2 shall be used. These tests shall apply to conductors and magnetic devices only.

4.12.8.1 Solder bath method - Power source parts shall be tested in accordance with Method 210 of MIL-STD-202. The following details shall apply:

a. Special preparation of specimen - Sample units shall not have been soldered during any of the previous tests.

b. Depth of immersion in the molten solder - To a point 1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal, whichever point is closer to the insulating material.

c. Test condition - A ($350 \pm 10^{\circ}C$; immersion, $3 \, {}^{+\frac{1}{2}}_{-0}$ seconds).

d. Examination after test - The parts shall be visually examined and there shall be no seepage of the impregnant, loosening of the terminals, or other mechanical damage. The parts shall be checked for continuity.

4.12.8.2 Soldering iron method - The test shall be performed on all solder terminations, attached to the power source parts. The solder shall conform to type S, composition of Sn60 of QQ-S-571. The flux shall conform to type A or W, as applicable, of MIL-F-14256. The temperature of the bit shall be 300° - $350^{\circ}C$. The iron and solder shall be applied to the termination for 10 seconds.

The solder shall be applied for the first 2 seconds. Tinning, as evidenced by the free flowing of the solder with proper wetting of the termination, shall be completed within the first two seconds. The parts under test shall remain under standard atmospheric conditions for recovery for fifteen minutes, before final measurements are made.

a. Special preparation of specimen - The surface shall be smooth and properly tinned and the solder terminations shall not have been soldered during any previous test.

b. Examinations after test - in accordance with 4.12.8.1.

c. Soldering irons - The soldering iron shall have one of the following bit sizes:

   (1) 0.3 inch diameter, 1.25 inch exposed length reduced to a wedge shape, over a length of approximately 0.4 inch.

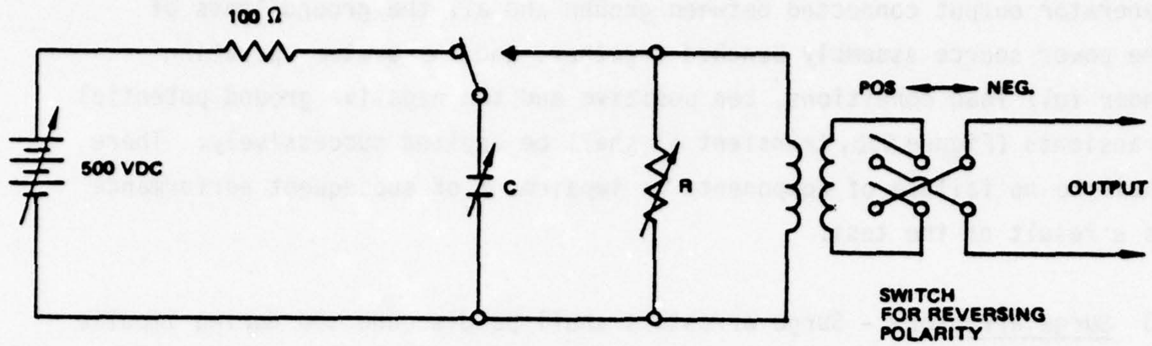
   (2) 0.125 inch diameter, 0.5 inch exposed length reduced to a wedge shape, over a length of approximately 0.2 inch.

d. Point of application of soldering iron - 1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal, whichever point is closer to the insulating material.

4.12.9 Grounding and bonding - Resistance measurements shall be conducted on at least two subassembly grounds, representative of the power source. Visual inspection shall be conducted in all power source subassembly and assembly grounds and bonds to the airplane structure. Bonds and grounds between the power source assembly and subassembly parts shall be in accordance with MIL-B-5087.

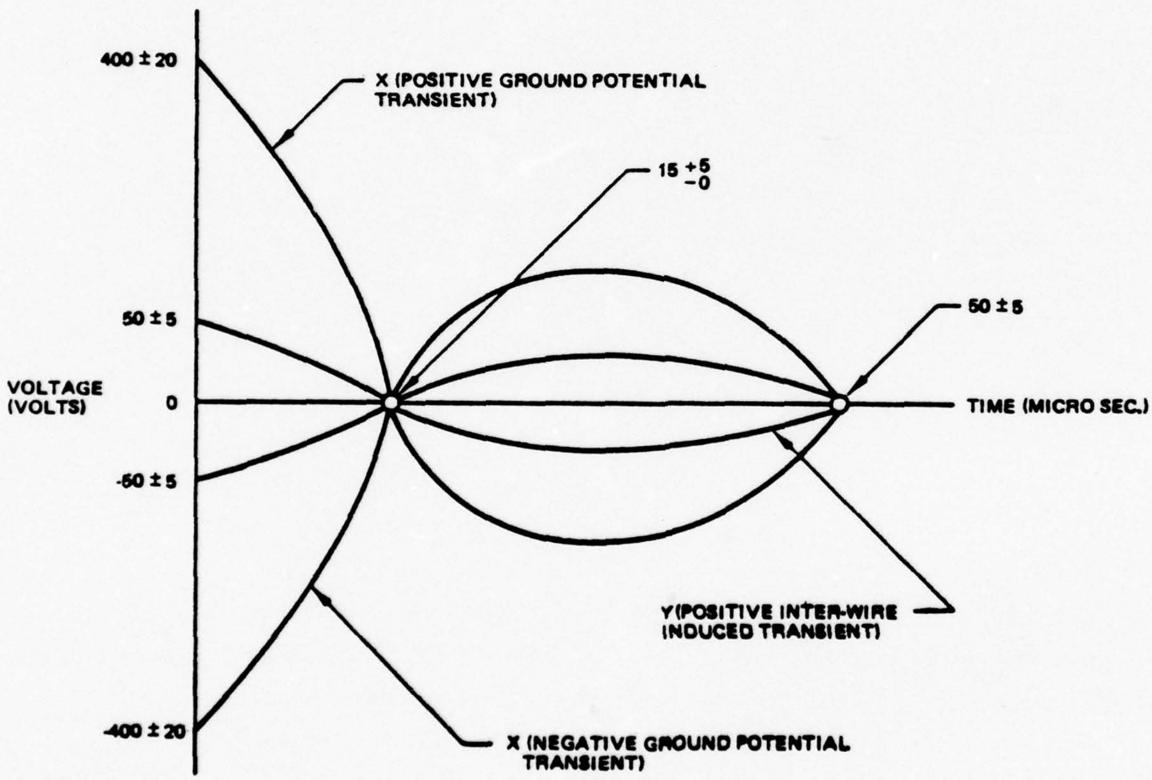
4.12.9.1 Grounding - The bonds selected shall be tested with a direct current source. The measured impedance with average transient current passing through the joint shall be less than 2.5 milliohms, maximum, between the power source assembly or subassembly and the airplane structure.

4.12.9.2 Lightning and electromagnetic pulse susceptibility test - A transient generator similar to that shown in Figure G5a shall be used. The voltage source, capacitor C, and resistor R shall be adjusted to obtain transient "X" in Figure G5b for ground potential transient susceptibility test, and "Y" for interwire induced transient susceptibility test.



TRANSIENT GENERATOR CIRCUIT

(A)



SHAPE OF LIGHTNING TRANSIENT

(B)

Figure G5: Transient Susceptability (See 4.12.9.2)

a. Ground potential transient susceptibility test - With the transient generator output connected between ground and all the ground leads of the power source assembly bunched together, and the system operating under full load conditions, ten positive and ten negative ground potential transients (Figure G5b, transient X) shall be applied successively. There shall be no failure of components or impairment of subsequent performance as a result of the test.

4.12.10 Surge arrestors - Surge arrestors shall be disconnected during impulse testing and dielectric withstanding voltage tests. Surge arrestors shall be tested by applying an impulse equal to the design surge voltage. The surge arrestor shall operate successfully for three consecutive impulses.

4.13 H.V. Evaluation tests - Power source assemblies and subassemblies with output voltages greater than 500 volts peak, shall be tested as specified in the following paragraphs.

4.13.1 Insulation resistance - The power source assembly and subassemblies shall be tested in accordance with Method 302 of MIL-STD-202. The following details and exceptions shall apply:

a. Test condition - B for qualification inspection; and dc test potentials from 500 volts to 10,000 volts for quality conformance inspection. However, for quality conformance inspection, rejection shall be based on measurements made at 500 volts.

b. The measurements shall be made at ambient room temperature, humidity, but rejections shall be based on measurements made at $25^{o}C\ ^{+10^{o}}_{-5^{o}C}$ and at a relative humidity not greater than 80 percent. Insulation resistance shall be greater than 100 megohms.

4.13.2 Dielectric withstanding voltage - Power source assemblies and subassemblies shall be tested in accordance with 4.13.2.1 and 4.13.2.2, when applicable.

4.13.2.1 Atmospheric pressure - Power source subassemblies shall be tested in accordance with method 301 of MIL-STD-202. The following details and exceptions shall apply:

a. Magnitude of test voltage shall be 160% of working voltage.

b. Nature of potential - ac or dc, as applicable.

c. Duration of application of specified test voltage - Minimum of 60 ±5 seconds for quality conformance inspection, 1 minute for qualification inspection.

d. Points of application of test voltage:

1. Input leads - Between input leads and case or ground. Sensors and control circuits connected between the input and ground shall be disconnected.

2. Output and ground - Sensors and control circuits connected to the high voltage output shall be disconnected.

3. Circuits with direct current rated capacitors shall be tested with dc of the proper polarity.

e. Examination during and after test - The assembly and subassemblies shall be examined for evidence of arcing, flashover, breakdown of insulation, and damage.

4.13.2.2 Altitude - Power source assemblies and subassemblies designed for operation above 10,000 feet shall be tested as specified in 4.13.2.1 and in accordance with method 105 of MIL-STD-202. The following detail and exceptions shall apply:

a. Test condition or altitude in feet if below 30,000 feet - As specified (see 3.2).

b. Magnitude of test voltage shall be 160% working voltage, ac or dc, as applicable, with polarity in accordance with tested parts.

c. Examination during and after test - Power source assemblies and subassemblies shall be examined for evidence of arcing, flashover, breakdown of insulation, and damage.

4.13.2.3 Special applications - High voltage coils and coil assemblies shall be tested individually to the voltage levels specified in paragraph 4.13.2.2b.

4.13.2.4 At reduced voltage - Power source assemblies and subassemblies after qualification shall be subjected to the dielectric-withstanding voltage tests specified in 4.13.2.1, except that the test voltages shall be 125% of the working voltage and shall be applied for a period of 60 seconds.

4.13.3 Partial discharges - When specified (see 3.2), power source subassemblies shall be tested in accordance with 4.13.3.1 or 4.13.3.2, or 4.13.3.3, as applicable. The detector used for this test shall have the sensitivity of one picocoulomb or less and shall have a reasonably uniform response up to 500 kilohertz. Partial discharge peak magnitudes shall be as defined in the detailed specification for a 10-minute test at rated voltage.

4.13.3.1 Input circuits - When specified (see 3.2), the generator high voltage auxiliary equipment input circuits shall be tested for partial discharges. Partial discharge peak magnitudes shall be less than 50 picocoulombs, or as defined in the detailed specification, during a 10-minute test at rated input voltage.

4.13.3.2 Output circuits - When specified, (see 3.2), the high voltage output circuit shall be tested for partial discharges. Partial discharge peak magnitudes shall be less than 500 picocoulombs during a 10-minute test at rated output voltage.

4.13.3.3 Operational - When specified (see 3.2), the partial discharge detector shall be connected to the power source high voltage output circuit and the unit shall be tested for partial discharges. Partial discharge peak magnitudes shall be less than 500 picocoulombs during a 5-minute test with the unit supplying rated voltage. The partial discharge test shall be started 10 seconds after rated voltage is stabilized. The output power shall be at full load.

4.13.4 Impulse - When impulse tests on line terminals are specified (see 3.2), they shall consist of and be applied in the following order: one reduced full wave, two chopped-waves, and one full wave in accordance with NEMA Pub. No. 109 and ASTM D1686.

4.13.4.1 Reduced full-wave test - For this test the applied voltage wave shall have a crest value of between 50 and 70 percent of the full wave value given in Tables 4 or 5 of American National Standard C57.12.00-1973 (IEEE Std 462-1973).

4.13.4.2 Chopped-wave test - For this test the applied voltage wave shall be chopped by a suitable air gap. It shall have a crest value and time to flashover in accordance with Tables 4 or 5 of American National Standard C57.12.00-1973 (IEEE Std 462-1973). This gap shall be located as close as possible to the terminals, and the impedance shall be limited to that of the necessary leads to the gap.

4.13.4.3 Connections for impulse tests - In general, the tests shall be applied to each terminal, one at a time.

4.13.4.4 Terminals not being tested - Neutral terminals shall be solidly grounded except in the case of low impedance windings. Line terminals shall be either solidly grounded or else grounded through a resistor with an ohmic value not in excess of the following values:

Nominal System Voltage (kV)	Resistance (Ohms)
345 & below	500
500	400
700	300

4.13.4.5 Wave to be used for impulse tests - A nominal 1.2 x 50 microsecond wave shall be used for impulse tests.

Positive or negative waves may be used for other than front-of-wave tests. The polarity shall be in accordance with the circuit polarity.

The time to crest shall not exceed 2.5 microseconds, except for circuits having large capacitance.

4.13.4.6 Voltage - The basic insulation voltage level to which the power source shall be tested is 350 percent rated voltage, or as defined in the detailed specification.

4.13.5 Electromagnetic interference - At no load or minimum load point, as applicable, half rated load, and rated load, radiated interference, and both the input and output conducted interference shall be measured using the test procedures and applicable instruments specified in Specification MIL-STD-462 per the requirements set forth in the detailed specification and MIL-STD-461.

5. PREPARATION FOR DELIVERY

5.1 Preservation-packaging - Preservation-packaging shall be level A or C, as specified.

5.1.1 Level A

5.1.1.1 Cleaning - Power source assemblies and subassemblies shall be cleaned in accordance with MIL-P-116, process C-1.

5.1.1.2 Drying - Subassemblies shall be dried in accordance with MIL-P-116.

5.1.1.3 Preservative application - Preservatives shall not be used.

5.1.1.4 Unit packaging - Power source assemblies and subassemblies shall be individually packaged in accordance with the unit packaging requirements of table G5 herein and MIL-P-116, insuring compliance with the general paragraph under methods of preservation (unit protection) and the physical protection requirements paragraph therein.

5.1.1.5 Intermediate packaging - Not required.

5.1.2 Level C - Assemblies and subassemblies shall be clean, dry, and individually packaged in a manner that will afford adequate protection against corrosion, deterioration, and physical damage during shipment from the supply source to the first receiving activity.

5.2 Packing - Packing shall be level A, B, or C, as specified.

5.2.1 Level A - the packaged assemblies and subassemblies shall be packed in accordance with the level A packing requirements of table G5. Boxes conforming to PPP-B-636 shall have all seams, corners, and manufacturer's joint sealed with tape, two inches minimum width, conforming to PPP-T-60, class 1, or PPP-T-76.

TABLE G5. Packaging method, unit supplementary and shipping container selection chart.

Unit packaging				Packing		
Net weight of item (pounds)	Grades	Packaging method or submethod of MIL-P-116	Unit or supplementary container	Level A	Level B	Level C
$\leq$2.99		III	PPP-B-566 or PPP-B-676	PPP-B-636, class weather resistant.	PPP-B-636, class domestic.	See 5.2.3
		IA-8 (unless otherwise specified, see 6.1)				
3.00-9.99		III	PPP-B-636, class domestic.	PPP-B-636, class weather resistant.	PPP-B-636, class domestic.	See 5.2.3
		IA-8 (unless otherwise specified, see 6.1)				
10.00-19.99		III	PPP-B-636, class weather resistant.	PPP-B-636, class weather resistant. PPP-B-640, class 2; PPP-B-601, overseas type; or PPP-B-621, class 2.	PPP-B-636, class domestic; PPP-B-640, class 1; PPP-B-601, domestic type or PPP-B-621, class 1.	See 5.2.3
		IA-14 (unless otherwise specified, see 6.1)	Inner container: PPP-B-636, class domestic. Outer container: PPP-B-636, class weather resistant.			
20.00-69.99		III	Unit container shall conform to the designated level of packing and shall serve as the shipping container.			See 5.2.3
		IA-14 (unless otherwise specified, see 6.1)	Inner container: PPP-B-636, class domestic. Outer container shall conform to the designated level of packing and shall serve as the shipping container.			
$\geq$70.00		III	Unit container shall conform to the designated level of packing and shall serve as the shipping container.	PPP-B-601, overseas type or PPP-B-621, class 2. When the weight exceeds 200 pounds, skids shall be applied in accordance with the applicable specification.	PPP-B-601, domestic type or PPP-B-621, class 1. When the weight exceeds 200 pounds, skids shall be applied in accordance with the applicable specification.	See 5.2.3

The closure, water-proofing, and banding requirements for the other level A shipping containers shown in table G5 shall be in accordance with the applicable box specification. Banding (reinforcement requirements) for all fiberboard containers (PPP-B-636 and PPP-B-640) shall be applied in accordance with the applicable appendix using non-metallic or tape banding only.

5.2.2 Level B - The packaged assemblies and subassemblies snall be packed as specified in 5.2.1, except that the containers shall conform to the level B packing requirements of table G5. Box closure shall be in accordance with the applicable box specification.

5.2.3 Level C - The packaged assemblies and subassemblies shall be packed in shipping containers in a manner that will afford adequate protection against damage during direct shipment from the supply source to the first receiving activity. These packs shall conform to the applicable carrier rules and regulations.

5.2.4 Unitized loads - Unitized loads, commensurate with the level of packing specified in the contract or order, shall be used whenever total quantities for shipment to one destination equal 40 cubic feet or more. Quantities less than 40 cubic feet need not be unitized. Unitized loads shall be uniform in size and quantities to the greatest extent practicable.

5.2.4.1 Level A - Assemblies and subassemblies, packed as specified in 5.2.1, shall be unitized on pallets in conformance with MIL-STD-147, load type I, with a fiberboard cap (storage aid 4) positioned over the load.

5.2.4.2 Level B - Assemblies and subassemblies, packed as specified in 5.2.2, shall be unitized as specified in 5.2.4.1 except that the fiberboards caps shall be class domestic.

5.2.4.3 Level C - Assemblies and subassemblies, packed as specified in 5.2.3, shall be unitized with pallets and caps of the type, size, and kind commonly used for the purpose and shall conform to the applicable carrier rules and regulations.

5.3 Marking - In addition to any special marking required by the contract or order, each unit package, supplementary and exterior container and unitized load shall be marked in accordance with MIL-STD-129.

5.4 General

5.4.1 Exterior containers - Exterior containers (see 5.2.1, 5.2.2 and 5.2.3) shall be of a minimum tare and cube consistent with the protection required and shall contain equal quantities of identical stock numbered items to the greatest extent practicable.

5.4.2 U.S. Air Force requirements-For U.S. Air Force requirements submethods IC-3 and IC-2 with supplementary container conforming to PPP-B-636, class weather resistant, special requirements shall be used in lieu of submethods IA-8 and IA-14, respectively (see table G5).

6. NOTES

6.1 Intended use - This specification covers power sources, which are intended to supply either alternating current into a high voltage high power converter or direct current into a high voltage high power converter.

6.2 Ordering data - Procurement documents should specify the following:

a. Title, number, and date of applicable detail specification.

b. MS Part number of the desired converter.

c. Accessories to be detached from the power source (see 3.4.3.13 through 3.4.3.17 and 3.5.3.7 through 3.5.7)

d. Mounting principle to be employed (see detailed specification)

e. Location of main power terminals, monitor and display cable connector (see 3.8)

f. Weight, size and configuration (see 3.8.11)

g. Whether shock design analysis is required (see 3.6.6)

h. Special vibration tests (see 3.6.7)

i. Responsibility for preparing final manuals, quantity, date required, and distribution of final technical manuals

j. Drawing list

k. Final drawings

l. Requirement for thermal and sound insulation (see 3.3.13)

m. Requirements for inspection tests (see 4.4)

n. Level of packaging and packing required (see 5.1)

o. Reinspection date marking required (see 5.3)

6.3 Qualification - With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E),Dayton, Ohio 45444 (see 3.2).

6.3.1 Submission of drawings - Upon notification of qualification approval, the manufacturer should provide two reproducible copies of outline and detail assembly drawings. Any changes in the reproducible copies from those submitted with the qualification samples should be indicated in detail.

6.3.2 Failure of samples - In case of failure of the sample or samples submitted, consideration will be given to the request of the manufacturer for additional tests only after it has been clearly shown that changes have been made in the product which the activity responsible for the qualification considers sufficient to warrant additional tests.

6.4 Service test - Service tests may be conducted by the procuring activity and will not subject the unit to conditions beyond the requirements of this specification. The tests will be conducted on new units to be provided by the procuring activity.

6.5 Definition - All ac voltages used in this specification should be rms values.

Notice: When Government drawings, specification, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that in any way be related thereto.

APPENDIX H

TRANSFORMERS

AND

INDUCTORS

TRANSFORMERS AND INDUCTORS
(HIGH VOLTAGE, HIGH POWER AND HIGH POWER PULSE)
GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for high voltage ,high power and high power pulse transformers and inductors for use in airborne equipment. This specification covers minimum weight and volume transformers and inductors having root-mean-square (rms) test-voltage ratings of 150,000 volts or less, and also high power pulse transformers where the peak pulse power is greater than 10 kilowatts and the average pulse power is greater than one kilowatt. Transformer and inductor assemblies incorporating any other active or passive components do not come within the scope of this specification.

1.2 Classification.

1.2.1 Type designation. The type designation shall be in the following form, and as specified (see 3.1 and 6.1):

TF	8	R	03	HV	203
Component (1.2.1.1)	Grade (1.2.1.2)	Class (1.2.1.3)	Family (1.2.1.4)	Envelope and mounting dimensions (1.2.1.5)	Identification number (1.2.1.6)

1.2.1.1 Component. Transformers and inductors are identified by the two-letter symbol "TF".

1.2.1.2 Grade. The grade is identified by a single digit denoting metal encased or encapsulated construction, and the ability of the transformers or inductors to withstand the environmental tests of Table H1.

1.2.1.2.1 Grades 7, 9, 10. These units are sealed, metal encased with either separately fabricated headers or terminals or both. This grade does not include units which are encapsulated in a metal shell with an opening in either end or side of the shell, or with insulated lead wires extending through the metal shell.

1.2.1.2.2 Grade 8. These units are encapsulated, including molded or embedded constructions, and units with a metal shell, open at one or both ends and filled with encapsulant material.

TABLE H1. GRADE

Test	Grade 7 metal encased	Grade 8 encap-sulated	Grade 9 liquid filled	Grade 10 gas pressurized
Seal	X	X	X	X
Thermal Shock	X	X	X	X
Immersion	X	X	X	X
Moisture resistance	X	X	X	X
Vibration	X	X	X	X
Shock	X	X	X	X
Flammability	---	X	X	---
Salt spray (when specified)	X	X	X	X

1.2.1.3 Class. The class is identified by a single letter in accordance with Table H2, and denotes the maximum operating temperature (temperature rise (see 4.8.11.19) plus maximum ambient temperature) (see 6.14.2.1 and 6.14.2.3).

TABLE H2. CLASS

Symbol	Maximum Operating Temperature ^{o}C
Q	85
R	105
S	130
V	155
T	170
U	>170, as specified (see 3.1)

1.2.1.4 Family (see 6.1). The family is identified by a two-digit symbol in accordance with table H3.

TABLE H3. Families.

03 - Power transformer

04 - Power inductor

37 - Charging inductor

1.2.1.5 <u>Envelope and mounting dimensions</u>. The envelope and mounting dimensions shall be specified in the detailed specification for configuration designated HV.

1.2.1.6 <u>Identification number</u>. The number identifies a specific transformer or inductor. This number will be assigned by the cognizant procurement agency when a coordinated specification sheet is approved.

1.2.2 <u>Connections</u>. The winding identification and numbering shall be assigned to identify the number of phases and connections as shown in Figure H1 for examples of three-phase and six-phase transformers.

THREE-PHASE TRANSFORMERS WITHOUT TAPS

Group 1
Angular
Displacement
0°

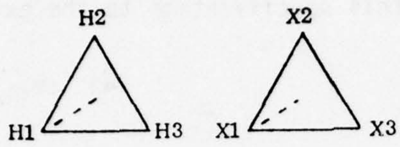


Fig. H1-1

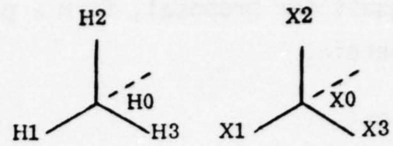


Fig. H1-2

Group 2
Angular
Displacement
30°

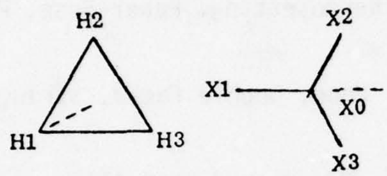


Fig. H1-3

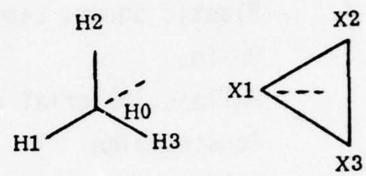


Fig. H1-4

SIX-PHASE TRANSFORMERS WITHOUT TAPS

Group 1
Angular
Displacement
0°

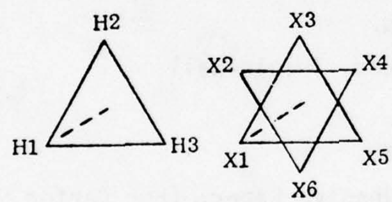


Fig. H1-5

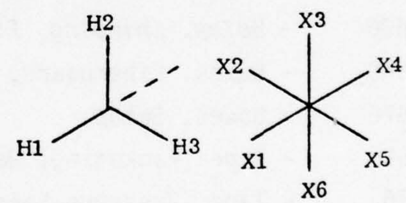


Fig. H1-6

Group 2
Angular
Displacement
30°

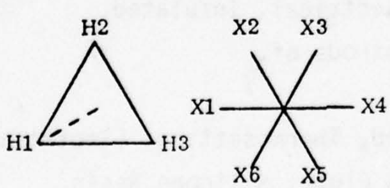


Fig. H1-7

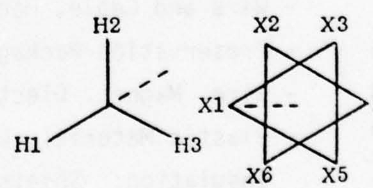


Fig. H1-8

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

J-W-1177	- Wire, Magnet, Electrical.
L-P-513	- Plastic Sheet, Laminated, Thermosetting, Paper-Base, Phenolic Resin.
NN-P-71	- Pallets, Material Handling, Wood, Double Faced, Stringer Construction.
QQ-S-571	- Solder, Tin Alloy; Tin-Lead Alloy; and Lead Alloy.
QQ-S-781	- Strapping, Steel, Flat and Seals.
PPP-B-566	- Boxes, Folding, Paperboard.
PPP-B-585	- Boxes, Wood, Wirebound.
PPP-B-601	- Boxes, Wood, Cleated-Plywood.
PPP-B-621	- Boxes, Wood, Nailed and Lock-Corner.
PPP-B-636	- Boxes, Shipping, Fiberboard.
PPP-B-640	- Boxes, Fiberboard, Corrugated, Triple-Wall.
PPP-B-676	- Boxes, Setup.
PPP-T-60	- Tape: Packaging, Waterproof.
PPP-T-76	- Tape, Pressure-Sensitive Adhesive Paper, (For Carton Sealing).

MILITARY

MIL-I-10	- Insulating Materials, Electrical, Ceramic, Class L.
MIL-M-14	- Molding Plastics and Molded Plastic Parts, Thermosetting.
MIL-W-76	- Wire and Cable, Hookup, Electrical, Insulated.
MIL-P-116	- Preservation-Packaging, Methods of.
MIL-W-583	- Wire, Magnet, Electrical.
MIL-P-997	- Plastic Material, Laminated, Thermosetting, Electrical Insulation: Sheets, Glass Cloth, Silicone Resin.
MIL-F-14256	- Flux, Soldering, Liquid (Rosin Base).
MIL-P-15037	- Plastic Sheet, Laminated, Thermosetting, Glass-Cloth, Melamine-Resin.

MIL-P-15047 - Plastic-Material, Laminated Thermosetting, Sheets, Nylon Fabric Base, Phenolic-Resin.

MIL-E-15090 - Enamel, Equipment, Light-Gray (Formula No. 111).

MIL-W-16878 - Wire, Electrical, Insulated, High Temperature.

MIL-P-18177 - Plastic Sheet, Laminated, Thermosetting, Glass Fiber-Base, Epoxy Resin.

MIL-B-43014 - Boxes: Water Resistant Paperboard; Folding, Set-Up, and Metal-Stayed.

MIL-C-45662 - Calibration System Requirements.

(See supplement 1 for list of associated specification sheets (or military standards.)

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.

MIL-STD-147 - Palletized Unit Loads on 40" x 48" Pallets.

MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.

MIL-STD-454 - Standard, General Requirements for Electronic Equipment.

MIL-STD-461 - Electromagnetic Interference Characteristics Requirements for Equipment.

MIL-STD-810 - Environmental Test Methods.

MIL-STD-1285 - Marking of Electrical and Electronic Parts.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

NEMA Publication No. 109 - AIEE-EEI-NEMA Standard Basic Insulation Level.

ASTM D1868 - Detection and Measurement of Discharge (Corona) in Evaluation of Insulation Systems.

American National Standard - C57.12.00-1973 - General Requirements for Distribution, Power, and Regulating Transformers.

APPENDIX A		- High Voltage Cable Criteria Document
APPENDIX B		- High Voltage Cable Assemble Criteria Document
APPENDIX D		- High Voltage Connector Criteria Document
APPENDIX F		- High Voltage Power Characteristics Criteria Document

NATIONAL BUREAU OF STANDARDS

Handbook H28 - Screw-Threads Standards for Federal Services

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.)

3. REQUIREMENTS

3.1 Specification sheets. The individual part requirements shall be as specified herein and in accordance with the applicable detailed specification sheets. In the event of any conflict between this specification and the detailed specification sheet, the latter shall govern (see 6.1).

3.2 Qualification. Transformers and inductors covered by specification sheets furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for the opening of bids (see 4.5 and 6.2). When there are no products listed or approved for listing on the qualified products list, the qualification requirement is waived only by the preparing activity; and procuring activities shall invoke first article inspection.

3.3 First article. Transformers and inductors not covered by specification sheets shall be as specified in the applicable complementary document (see 6.1.2). These products shall have been tested and passed first article inspection in 4.6 and 6.3. This inspection consists of meeting all of the qualification tests of 4.5 through 4.5.1.3, inclusive and table H5.

3.3.1 Information to be furnished with first article sample. The applicable information outlined in 6.1.2 shall be furnished with the first article sample, together with any other pertinent information as required by the Government.

3.4 Materials. The materials shall be as specified herein; however, when a definite material is not specified, a material shall be used which will enable the transformers and inductors to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.4.1 Substitution of materials. If the supplier desires to substitute another material for a specified material or fabricated part, he shall submit a statement to the Government describing the proposed substitution, together with evidence to substantiate his claims that such substitute is suitable. At the discretion of the Government, test samples may be required to prove the suitability of the proposed substitute. Before such substitutions are made, approval for each substitution shall be obtained in writing from the Government.

3.4.2 Flammable materials. Insofar as practicable, materials used in the construction of transformers and inductors shall be nonflammable and nonexplosive.

3.4.3 Corrosive materials. Corrosive materials used in any of the manufacturing processes shall be removed or neutralized so that no corrosion will result from such use. Insofar as practicable, materials used in the construction of transformers and inductors shall be noncorrosive.

3.4.4 Insulating materials.

3.4.4.1 Laminated phenolic. Laminated phenolic materials shall conform to MIL-P-997, L-P-513, MIL-P-15037, or MIL-P-15047. When electrical characteristics are involved, only natural uncolored materials shall be used.

3.4.4.2 Molded phenolic or melamine. Molded phenolic or melamine materials shall conform to MIL-M-14.

3.4.4.3 Ceramic (external use). Ceramic materials shall conform to MIL-I-10.

3.4.4.4 Laminated plastic sheet. Laminated plastic sheet, epoxy, shall conform to MIL-P-18177.

3.4.5 Wire. Internal wiring of a transformer or inductor is considered to be all the interconnecting wiring beyond the point where the power supply enters the enclosure.

3.4.5.1 Magnet wire. Magnet wire shall conform to and be of the types and sizes specified in Federal specification J-W-1177 and MIL-W-583. Government approval shall be required when other types and sizes of magnet wire are used.

3.4.5.2 Insulated wire. When insulated wire is used as wire terminals, the wire shall be of the types and sizes covered in MIL-W-76, MIL-W-16878 or the H.V. cable criteria document. Government approval shall be required when other types and sizes of insulated wire are used as terminals.

3.4.5.3 Wire support. All wire, cable and buses shall be supported and arranged so they will withstand abrasion, flexing, and vibration. Clamping shall be such that it will not damage the insulation.

3.4.6 Solder and soldering flux. Solder, when used, shall be in accordance with QQ-S-571. Soldering flux shall be in accordance with MIL-F-14256.

3.4.7 Screws, nuts, bolts, and washers. All mounting and terminal screws, nuts, bolts, and washers shall be of corrosion-resistant material or shall be protected against corrosion.

3.5 Design and construction.

3.5.1 Mounting and terminal screws and mounting inserts. Screw threads shall be Class 2A or 2B, as applicable (see 3.1), in accordance with Handbook H28. External screw threads, class 2 fit, shall, after receiving a finish, be capable of accepting a nut of class 2B fit and internal screw threads, class 2 fit, shall, after receiving a finish, be capable of accepting a screw of class 2A fit. Maximum installation torque shall be as specified in the detailed specification. Nuts shall run down to within two threads of mounting surface or washer surface.

3.5.2 Terminals (see 3.1 and 6.1.2).

3.5.2.1 Solder terminals (see 4.8.2.2). Solder terminals may be of any shape and shall be capable of complying with solderability requirements of this specification. The height of the solder terminal shall be considered as the maximum distance from the terminal mounting surface to the highest point, including the additional height obtained if semiflexible terminals are straightened. It is not intended that the "hook" in the hook-type terminal be straightened from its normal hooked position. The type of terminal and the maximum size of wire which the terminal will accept externally shall be as specified in the detailed specification (see 3.1 and 6.1.2).

3.5.2.2 Case as terminal. When the case is used as a terminal, any protective coating applied to the mounting surfaces shall be such as to provide a direct conducting path for an electric current from the case to the surface on which it is mounted.

3.5.2.3 Bushings. The basic insulation level of line bushings shall be as specified in paragraph 4.8.13.7.

3.5.2.4 Terminal insulators. Terminal insulators shall be glass or ceramic.

3.5.2.5 Connectors. Connectors shall be hermetically sealed, circular threaded, as specified in the high voltage criteria document, Appendix D.

3.5.2.6 Screw terminals. When specified (see 3.1, 6.1.1 and 6.1.2), external screw terminals shall be supplied with two nuts, two flat washers, and one lock-washer. For cased units, the height of the terminal assembly shall be the distance from the free end of the screw to the terminal mounting surface. The type of terminal, size of screw thread, and the exposed length of threads ±.062 inch shall be as specified (e.g., screw,0.164-32 UNC x0.375) (see 3.1 and 6.1.2).

3.5.2.7 Corona protected bushing insulator. When specified (see 3.1 and 6.1.2), terminals shall be supplied with a corona suppressor where the terminal and terminal hardware are shielded by an angle of at least 30 degrees by corona suppressor cavity. Terminal hardware shall consist of two nuts, one flat washer and one lock washer,or shall consist of one flat washer, one lock washer and one cap screw. The terminal post shall not have external threads below the corona suppressor in the bushing. Terminal post finish shall be 100 microns or smoother. The height of the terminal assembly shall be the distance from the top of the corona suppressor to the terminal mounting surface. The type of terminal shall be specified (see 3.1 and 6.1.2).

3.5.3 Lifting, moving, and jacking facilities.

3.5.3.1 Safety factor. Lifing, moving, and jacking facilities shall be designed to provide a safety factor of 5. This safety factor is the ratio of the ultimate stress of the material used to the working stress. The working stress is the maximum combined stress developed in the lifting facilities by the static load of the component being lifted.

3.5.3.2 Lifting facilities. Lifting facilities shall be provided for lifting the cover separately, and also for lifting the core and coil assembly from the housing using one to four lifting cables.

Facilities for lifting the complete transformer (with the cover securely fastened in place) shall be provided. Lifting facilities shall be designed for lifting with one to four slings at a maximum angle of 30 degrees with respect to the vertical. The bearing surfaces of the lifting facilities shall be free from sharp edges and shall be provided with a hole having a minimum diameter of 13/16 inch (20.6 mm) for guying purposes.

3.5.3.3 Moving facilities. The base of the transformer shall be of heavy plate or have members forming a rectangle that will permit rolling in the directions of the centerlines of the segments.

3.5.3.4 Jacking facilities. Jacking facilities shall be located near the extreme ends of the corners of the case.

3.5.3.5 Mounting. The points of support shall be so that the inductive unit will withstand the variable orientation of the airplane.

3.5.3.6 Mounting studs. When specified (see 3.1, 6.1.1 and 6.1.2), external mounting studs shall be provided with a flat washer and locknut, or with a flat washer, lockwasher, and a nut.

3.5.4 Internal wire leads. Internal wire leads shall be attached to the coils, bushings, and other internal components and terminals or case by soldering, welding, brazing, or other method (e.g., lead-sweating, nylon-coated wires or bolts) in such a manner as to provide adequate electrical connection and mechanical strength. Where soft solder is used to provide the electrical connection, wire leads shall be anchored mechanically.

3.5.5 Core and coil mounting. Cores and coils shall be secured rigidly to prevent any permanent change in the relative position of the parts. The means of securing the core and coil to the devices for mounting the transformer or inductor in the equipment (e.g., studs, lugs, inserts, brackets, etc.) shall not depend on soft solder alone for mechanical strength, nor shall the transmission of the mechanical load of the core to the mounting device depend only on soft solder. When specified (see 3.1 and 6.1.2), the core shall be grounded to the case or shall be electrically accessible.

3.5.6 Paint composition and color. When a paint finish is specified (see 3.1 and 6.1.2), the color of the paint shall be light gray, semigloss, formula No. 111, as specified in MIL-E-15090 or as specified in the detailed specification. Unless otherwise specified (see 3.1 and 6.1.2), the manufacturer shall omit paint from the mounting area surface.

3.5.7 Potting, filling, or encapsulating material. The amount and coverage of potting, filling, or encapsulating material used shall be essentially the same for all units of a specific design. Potting, filling, or encapsulating material shall not flow from the case of the transfermer or inductor during any of the applicable tests.

3.6 Solderability. When transformers and inductors are tested as specified in 4.8.2, they shall meet the applicable criteria for terminal evaluation in the test method.

3.7 Resistance to solvents. When transformers and inductors are tested as specified in 4.8.3, there shall be no evidence of mechanical damage and the markings shall remain legible. The paint or exterior finish shall not soften, peel or show other signs of deterioration.

3.8 Thermal shock. When transformers and inductors are tested as specified in 4.8.4, there shall be no leakage of filling material, no evidence of other physical damage such as cracks, bursting, or bulging of the case or corrosion affecting the mechanical or electrical operation.

3.9 Resistance to soldering heat. When transformers and inductors are tested as specified in 4.8.5, there shall be no softening of the insulation or loosening of the windings or terminals.

3.10 Terminal strength. When transformers and inductors are tested as specified in 4.8.6, there shall be no evidence of loosening or rupturing of the terminals, or other mechanical damage. Bends shall not be considered as damage unless surface cracking is evident. Except for flexible leads, there shall be no rotation of the terminals. Rotation of the external portion of the metallic portion of a "hook" type terminal of less than 10 degrees shall not constitute a failure.

3.11 Seal (see 4.8.7).

3.11.1 Liquid-filled units. When transformers and inductors are tested as specified in 4.8.7.1, there shall be no evidence of liquid leakage.

3.11.2 Gas-filled units. When transformers and inductors are tested as specified in 4.8.7.2, the leak rate shall not exceed 1×10^{-8} standard atmosphere cubic centimeter per second (atm cm^3/s).

3.11.3 Pressure-vacuum transducer. A pressure-vacuum transducer shall be furnished for transformers of the sealed-tank and gas-oil-seal constructions.

3.11.4 Liquid temperature transducer. A liquid temperature transducer shall be furnished for transformers of the sealed tank liquid filled construction.

3.11.5 Pressure-vacuum bleeder. A pressure-vacuum bleeder device shall be set to operate at the maximum operating pressure (positive and negative) indicated on the nameplate. Transformer effluent gases/liquids shall be ported overboard the aircraft.

3.11.6 Tanks. Tanks shall be designed for vacuum filling in the field. A pressure relief device shall be provided on the cover. Maximum operating pressures (positive and negative) for which the transformer is to be operated shall be indicated on the nameplate.

3.11.7 Fans, pumps and control. The equipment for automatic control of fans or pumps for forced air cooled or liquid cooled transformers shall be thermally controlled with a manual override switch in parallel with the automatic control. Contacts and sensors shall be enclosed inside the transformer tank.

3.11.8 Surge Arestors. When specified, a surge arrestor ground pod consisting of a tank ground pod, mounted near the high voltage terminals shall be available for surge protection.

3.11.9 All other units. When transformers and inductors are tested as specified in 4.8.7.3, there shall be no continuous flow of air bubbles or leakage of compound from the body of the units. When the coil is individually encapsulated, bubbles from the space between the coil and laminations shall not be considered a failure provided the seal of the coil has been previously tested.

3.12 Dielectric withstanding voltage. When transformers and inductors are tested as specified in 4.8.8, there shall be no evidence of arcing, flashover, breakdown of insulation, or damage determined by visual inspection and reduced insulation resistance and increased partial discharge magnitudes.

3.13 Induced voltage. When transformers and inductors are tested as specified in 4.8.9, there shall be no evidence of continuing arcing or breakdown of insulation, nor shall there be any abrupt changes in the input current, or Q, as applicable.

3.14 Insulation resistance. When measured as specified in 4.8.10, the minimum insulation resistance shall be greater than the value specified for the insulation system in the applicable specification.

3.15 Electrical characteristics. When transformers and inductors are tested as specified in 4.8.11, the applicable electrical characteristics and tolerances shall be as specified (see 3.1 and 6.1.2).

3.15.1 Polarity. Transformer winding polarity shall be determined as specified in 4.8.11.9, or as specified (See 3.1 or 6.1.2).

3.15.2 Turns ratio. When a transformer has taps or multiple windings, the turns ratio shall be determined for all taps as well as for the full windings as outlined in 4.8.11.12 or as specified (see 3.1 and 6.1.2).

3.15.3 D.C. resistance and resistive unbalance. When transformers and inductors are tested as specified in 4.8.11.3, the d.c. resistance shall be measured at or corrected to 20°C. The resistive unbalance of center tapped windings in percent $\left(\frac{R_1 - R_2}{R_1}\right)$ shall be computed.

3.15.4 Primary impedance. When transformers are tested as specified in 4.8.11.6, the primary winding impedance shall be measured with secondaries loaded to normally loaded impedance, including d.c. currents flowing in the windings.

3.15.5 Core loss. When transformers are tested as specified in 4.8.11.14, excitation losses consisting principally of the transformer core losses shall be measured or as specified (see 3.1 and 6.1.2).

3.15.6 Insulation power loss. Winding insulation losses for transformers and inductors shall be tested as specified in 4.8.11.15, or as specified (see 3.1 and 6.1.2).

3.15.7 Bushings. When tests are required on bushings separately from the transformers, the tests shall be as specified in 4.8.11.16.

3.15.8 No load. When transformers are tested under no load conditions, measurements shall be made with the secondary windings open circuited, as outlined in 4.8.11.1 or as specified (see 3.1 and 6.1.2).

3.15.9 Efficiency and regulation. When transformers and inductors are tested as specified in 4.8.11.2 efficiency and regulation shall be measured at 50% load,full load and 125% load. Load impedance shall include but not be limited to power factors of 1.0, 0.8 lag and 0.9 lead. The exact regulation is given by:

$$\sqrt{(r + p)^2 + (x + q)^2} - 1 \qquad \text{for lagging loads}$$

$$\sqrt{(r + p)^2 + (x - q)^2} - 1 \qquad \text{for leading loads}$$

where

p = power factor of load

$q = +\sqrt{1 - p^2}$

x = leakage reactance of the transformer

r = dc resistance of the transformer

3.15.10 Short circuit. Short circuit leakage impedance, primary to secondary and half-winding to half-winding shall be measured as outlined in 4.8.11.13, or as specified (see 3.1 or 6.1.2).

3.15.11 Inductance and inductive unbalance. Inductance and inductive unbalance of transformers and inductors shall be calculated or measured at operating frequency with the specified d.c. current applied, as specified in 4.8.11.4, or as specified (see 3.1 or 6.1.2).

3.15.12 Harmonic distortion. When transformers or inductors are tested as specified in 4.8.11.5, the harmonic distortion shall be measured or computed, or as specified (see 3.1 and 6.1.2).

3.15.13 Self-resonant frequency. The self resonant frequency of transformers and inductors shall be measured as specified in 4.8.11.7, or as specified (see 3.1 or 6.1.2).

3.15.14 Storage factor. When inductors are tested as specified in 4.8.11.10, the energy storage factor shall be measured or computed, or as specified (see 3.1 or 6.1.2).

3.15.15 Wave shape. Transformers or inductors having non-sinusoidal wave shapes shall be tested as specified in 4.8.11.11, or as specified (see 3.1 or 6.1.2).

3.16 Temperature rise. When transformers and inductors are tested as specified in 4.8.11.19, the temperature rise of any winding above the specified maximum ambient temperature (see 3.1 and 6.1.2) shall not exceed the value specified (see 3.1 and 6.1.2), and there shall be no evidence of physical damage.

3.17 Partial discharges (when specified, see 3.1 and 6.1.2). When transformers and inductors are tested as outlined in 4.8.13 or as specified (see 3.1 and 6.1.2), the partial discharge maximum magnitudes shall not exceed 100 picocoulombs (peak) at rated voltage.

3.18 Impulse. When transformers and inductors are tested as outlined in 4.8.13 or as specified (see 3.1 and 6.1.2),they shall consist of and be applied in the following manner:

one reduced full-wave,
two chopped waves
one full wave.

Impulse tests shall be made without excitation.

3.18.1 Terminals not being tested. Neutral windings, low voltage windings and instrumentation and control equipment shall be grounded during impulse tests.

3.19 Electromagnetic Compatibility. When transformers or inductors are tested as specified in 4.8.11.8, the assembly shall have a shielding effectiveness of 15 dB minimum, and electrical field effectiveness of 45 dB minimum.

3.20 Altitude. When tested as specified in 4.8.8.2, the transformer or inductor shall meet the partial discharge and voltage breakdown requirements (see 3.12 and 3.17). Any evidence of dielectric breakdown, arcing, or flashover within the transformer envelope shall be cause for rejection.

3.21 Salt spray (corrosion) (when specified, see 3.1 and 6.1.2). When transformers and inductors are tested as specified in 4.8.14, there shall be no evidence of corrosion as exhibited by any visible degradation of the surfaces that can be attributed to flaking, pitting, blistering or otherwise loosened protective coating or metal surface.

3.22 Vibration. When transformers and inductors are tested as specified in 4.8.15, there shall be no leakage of filling material, no evidence of other physical damage such as cracks, bursting, or bulging of the case.

3.23 Shock. When transformers and inductors are tested as specified in 4.8.16, there shall be no leakage of filling material, no evidence of other physical damage such as cracks, bursting, or bulging of the case.

3.24 Winding continuity. When transformers and inductors are tested as specified in 4.8.17, all windings shall be electrically continuous.

3.25 Immersion. When transformers and inductors are tested as specified in 4.8.18, there shall be no leakage of filling material, no evidence of other physical damage such as cracks, bursting, or bulging of the case or corrosion affecting the mechanical or electrical operation.

3.26 Moisture resistance. When transformers and inductors are tested as specified in 4.8.19, there shall be no leakage of filling material, no evidence of other physical damage such as cracks, bursting, or bulging of the case or corrosion affecting the mechanical or electrical operation.

3.27 Overload. When transformers and inductors are tested as specified in 4.8.20, there shall be no leakage of filling material, no evidence of other physical damage such as cracks, bursting, or bulging of the case.

3.28 Visual and machanical examination (post test). When transformers and inductors are examined as specified in 4.8.1.1.1, not more than 10 percent of the surface shall have peeling, flaking, chipping, cracking, crazing, or other impairment of the protective coating. There shall be no leakage of the filling material, no evidence of other physical damage, such as cracks, bursting, or bulging of the case or corrosion affecting the mechanical or electrical operation of the units.

3.29 Flammability (grade 5). When transformers and inductors are tested as specified in 4.8.21, there shall be no evidence of violent burning which results in an explosive-type fire, and the coating material used on the transformers and inductors shall be self-extinguishing. A transformer or inductor shall not be

considered to have failed, in the event that it is consumed by the applied flame, unless dripping of flaming material or an explosive-type flame has occurred. A transformer or inductor shall be considered to have failed only if an explosion of dripping of flaming material occurs, an explosive-type flame is produced, or if visible burning continues beyond the allowable duration of 3 minutes after removal of the applied flame. Material will be considered self-extinguishing if the following conditions are met:

(a) The duration of visible flame does not exceed 3 minutes after removal of the applied flame.

(b) There is no explosion, nor any violent burning which results in an explosive-type flame.

(c) There is no dripping of flaming material from the transformer or inductor under test.

3.30 Life. When transformers and inductors are tested as specified in 4.8.22, there shall be no evidence of physical or electrical damage as indicated by an open circuit (a break in the continuity of any electrical circuit within the transformer or inductor being tested) or short circuit occurring within the transformer or inductor (such as shorted turns or faulty insulation between layers, between turns, between windings, between windings and case or core, or between windings and shield). In addition, transformers and inductors shall meet the following requirements:

(a) Insulation resistance - Shall be as specified in 3.14.

(b) Dielectric withstanding voltage (at atmospheric pressure) - Shall be as specified in 3.12.

(c) Induced voltage - Shall be as specified in 3.13.

The electrical characteristics shall remain within the limits detailed in the detailed specification. All transformers and inductors furnished under this specification shall have a life expectancy as specified in the detailed specification.

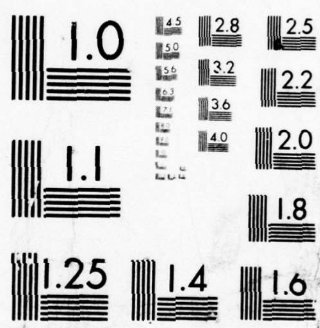
3.31 Fungus. All external materials shall be nonnutrient to fungus growth or shall be suitably treated to retard fungus growth. The manufacturer shall certify that all external materials are fungus resistant (see 4.8.23) or shall perform the test specified in 4.8.23. There shall be no evidence of fungus growth on the external surfaces.

AD-A069 473 BOEING AEROSPACE CO SEATTLE WASH F/G 9/5
HIGH VOLTAGE SPECIFICATIONS AND TESTS (AIRBORNE EQUIPMENT). (U)
APR 79 W G DUNBAR, W P KOENIG F33615-77-C-2054

UNCLASSIFIED AFAPL-TR-79-2024 NL

6 OF 6
AD
A069473

END
DATE
FILMED
7--79
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

3.32 Marking. Transformers and inductors shall be marked with the military part number, manufacturer's part number, manufacturer's code symbol, terminal identification and date code and lot symbols in accordance with method I, MIL-STD-1285 (see 3.29.1 through 3.29.6). Markings shall remain legible after all tests. Any markings of a classified nature shall not be included. Unless otherwise specified (see 3.1 and 6.1.2), the following additional information as applicable to the individual families, shall be included.

3.32.1 Family 03. Rated voltage and frequency of primary, rated voltages and currents of secondaries, working voltages to ground for each winding, working voltages between windings whenever they exceed any of the applicable working voltages to ground, and the altitude if greater than 10,000 feet.

3.32.2 Families 04, 37. Rated inductance at nominal frequency and voltage, ac voltage and frequency, dc current, dc resistance, working voltages to ground, working voltages between windings whenever they exceed any of the applicable working voltages to ground, and the altitude if greater than 10,000 feet.

3.32.3 Families 40 and 41. Maximum control current, impedance, impedance variation, rated voltages and frequency (as applicable), maximum feedback current (if any), bias current (if any), operating power level, working voltages to ground, and working voltages between windings whenever they exceed any of the applicable working voltages to ground, and the altitude if greater than 10,000 feet.

3.32.4 Terminal identification. Unless otherwise specified (see 3.1 and 6.1.2), terminals shall be identified by appropriate numbers as shown in Figure H1.

3.32.5 Serial Number. Each transformer and inductor shall have a serial number. All design and test data shall be traceable to the serial number.

3.33 Workmanship. Transformers and inductors shall be processed in such a manner as to be uniform in quality and shall meet the requirements of 3.3, 3.4 and 3.5 as applicable, and shall be free of defects that will affect life serviceability or appearance.

4. QUALITY ASSURANCE PROVISIONS

4.1 <u>Responsibility for inspection</u>. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 <u>Test equipment and inspection facilities.</u> Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the inspection facility. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-C-45662.

4.2 <u>Classification of inspections</u>. The inspections specified herein are classified as follows:

(a) Materials inspection (see 4.3).
(b) Qualification inspection (see 4.5).
(c) First article inspection (see 4.6).
(d) Quality conformance inspection (see 4.7).

4.3 <u>Materials inspection</u>. Materials inspection shall consist of certification supported by verifying data that the materials listed in table H4 used in fabricating the transformers and inductors, are in accordance with the applicable referenced specifications or requirements prior to such fabrication.

TABLE H4. <u>Materials inspection</u>.

Materials	Requirement paragraph	Applicable specification
Insulating material:		
Laminated phenolic - - - -	3.4.4.1	MIL-P-997, L-P-513, MIL-P-15037, or MIL-P-15047
Molded phenolic or melamine-	3.4.4.2	MIL-M-14
Ceramic (external use)- - -	3.4.4.3	MIL-I-10
Laminated Plastic Sheet- - -	3.4.4.4	MIL-P-18177
Wire:		
Magnet wire - - - - - - - - - -	3.4.5.1	J-W-1177
Insulated wire - - - - - - - --	3.4.5.2	MIL-W-76 or MIL-W-16878

4.4 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202 and MIL-STD-454.

4.4.1 Test frequency. When a test frequency is specified herein, the frequency used shall be within ±2 percent of the nominal value. The test frequency of transformers and inductors shall be the geometric mean of the specified frequency range or a lower value selected by the manufacturer.

4.4.2 Test voltage. For transformers and inductors, the rated rms voltage at the minimum frequency of the specified frequency range shall be applied at the rated duty cycle (e.g., transformers rated at 50/60 Hertz (Hz) shall be tested at 50 Hz; transformers and inductors rated at 60 Hz ±10 percent shall be tested at 60 Hz). When rated primary voltages are specified with a tolerance (see 3.1 and 6.1.2), the test voltage shall be the rated voltage (e.g., 115 ±10 volts shall be tested at 115 volts). For two terminal primary windings where the rated primary voltage is specified as a range, the test voltage shall be the arithmetic mean of the range. For multitap primary windings where a range of voltages are specified, the test voltage shall be applied to the highest voltage in the range and applied to the appropriate terminals (e.g., 105 to 125 volts shall be tested at 125 volts). For dielectric withstanding voltage tests, the peak of the voltage applied shall not exceed by more than 5 percent the peak of the pure sine voltage.

4.5 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.2) on sample units produced with equipment and procedures normally used in production.

4.5.1 Qualification of transformers and inductors based on complete testing.

4.5.1.1 Sample size. A sample of one unit shall be comprised of a high voltage transformer or inductor and shall be submitted for inspection.

4.5.1.2 Inspection routine. The sample units shall be subjected to the inspections specified in table H5, in the order shown and as specified in paragraph 20 to this specification.

4.5.1.3 Failure. One or more failures of the specified qualification inspection tests listed in Table H5 shall be cause for refusal to grant qualification approval.

4.5.2 Qualification inspection of transformers and inductors based on similarity. Qualification inspection shall be performed only on those transformers and inductors which meet the requirements of 20.2 of the appendix.

4.5.2.1 Sample size. A sample of one unit shall be comprised of a high voltage transformer or inductor and shall be submitted for inspection.

4.5.2.2 Inspection routine. Sample units shall be subjected to the qualification inspection in table H6, in the order shown.

4.5.2.3 Failure. One or more failures of the specified qualification inspection for transformers and inductors similar to transformers and inductors that have been qualified in tests listed in Table H6 shall be cause for refusal to grant qualification approval

TABLE H5. Qualification inspection.

Examination or test	Grade 7	8	9	10	Requirement paragraph	Method paragraph
Group I						
Solderability 1/	X	X	X	X	3.6	4.8.2
Resistance to solvents	X	X	X	X	3.7	4.8.3
Group II						
Thermal shock (when specified) (25 cycles)	X	X	X	X	3.8	4.8.4
Visual and mechanical examination (external)	X	X	X	X	3.1, 3.4 to 3.4.4.4 incl., 3.5 to 3.5.2.7 incl., 3.5.3, 3.5.7, 3.32 and 3.33	4.8.1
Resistance to soldering heat	X	X	X	X	3.9	4.8.5
Terminal strength	X	X	X	X	3.10	4.8.6
Seal	X	X			3.11 to 3.11.2 incl.	4.8.7
Pressure vacuum transducer			X	X	3.11.3	4.8.7.3.1
Liquid temperature transducer			X		3.11.4	4.8.7.3.1
Pressure vacuum bleeder			X	X	3.11.5	4.8.7.3
Tanks			X	X	3.11.6	4.8.7.3
Fans, Pumps and Control	X	X	X	X	3.11.7	4.8.7.3.2
Surge arrestors	X	X	X	X	3.11.8	4.8.7.3.3
Dielectric withstanding voltage:						
At atmospheric pressure	X	X	X	X	3.12	4.8.8.1
At altitude	X	X	X	X	3.12	4.8.8.2
Induced voltage	X	X	X	X	3.13	4.8.9
Insulation resistance	X	X	X	X	3.14	4.8.10
Polarity	X	X	X	X	3.15.1	4.8.11.9
Turns ratio	X	X	X	X	3.15.2	4.8.11.12
DC resistance and resistance unbalance	X	X	X	X	3.15.3	4.8.11.3

TABLE H5. Qualification inspection (cont.)

Examination or test	Grade 7	8	9	10	Requirement paragraph	Method paragraph
Primary impedance	X	X	X	X	3.15.4	4.8.11.6
Core loss	X	X	X	X	3.15.5	4.8.11.14
Insulation power loss	X	X	X	X	3.15.6	4.8.11.15
Bushings	X	X	X	X	3.15.7	4.8.11.16
No load	X	X	X	X	3.15.8	4.8.11.1
Efficiency and regulation	X	X	X	X	3.15.9	4.8.11.2
Short circuit	X	X	X	X	3.15.10	4.8.11.13
Inductance and inductance unbalance	X	X	X	X	3.15.11	4.8.11.4
Harmonic distortion	X	X	X	X	3.15.12	4.8.11.5
Self resonant frequency	X	X	X	X	3.15.13	4.8.11.7
Storage factor	X	X	X	X	3.15.14	4.8.11.10
Wave Shape	X	X	X	X	3.15.15	4.8.11.11
Temperature rise	X	X	X	X	3.16	4.8.11.19
Partial discharge	X	X	X	X	3.17	4.8.12
Impulse	X	X	X	X	3.18	4.8.13
Terminals not being tested	X	X	X	X	3.18.1	4.8.11.17
Electromagnetic compatibility	X	X	X	X	3.19	4.8.11.8
Altitude	X	X	X	X	3.20	4.8.11.18
Group III						
Salt spray (when specified)	X	X	X	X	3.21	4.8.14
Vibration	X	X	X	X	3.22	4.8.15
Shock	X	X	X	X	3.23	4.8.16
Dielectric withstanding voltage:						
At reduced voltage	X	X	X	X	3.12	4.8.8.3
Thermal shock (10 cycles)	X	X	X	X	3.8	4.8.4
Immersion	X	X			3.25	4.8.18
Moisture resistance	X	X	X	X	3.26	4.8.19
Dielectric withstanding voltage:						
At reduced voltage	X	X	X	X	3.12	4.8.8.3
Overload	X	X	X	X	3.27	4.8.20
Dielectric withstanding voltage:						
At reduced voltage	X	X	X	X	3.12	4.8.8.3
Visual and mechanical examination (internal)	X	X	X	X	3.1, 3.4 to 3.4.4.4 incl. 3.5.3, 3.5.4 3.5.6 & 3.32	4.8.1.2
Flammability		X			3.29	4.8.21
Group IV						
Life	X	X	X	X	3.30	4.8.22
Dielectric withstanding voltage:						
At reduced voltage	X	X	X	X	3.12	4.8.8.3
Insulation resistance	X	X	X	X	3.14(c)	4.8.10
Induced voltage	X	X	X	X	3.13	4.8.9
Partial discharge	X	X	X	X	3.17	4.8.12
Visual and mechanical examination (external)	X	X	X	X	3.1, 3.4 to 3.4.4.4 incl., 3.5 to 3.5.2.7 incl. 3.5.3, 3.5.7, 3.32 and 3.33	4.8.1.1

TABLE H5. Qualification inspection (cont.)

Examination or test	Grade 7	Grade 8	Grade 9	Grade 10	Requirement paragraph	Method paragraph
Group V						
Fungus 2/	X	X	X		3.31	4.8.23

1/ Solderable type terminals only: If the soldering iron method (4.8.2.2) of the solderability test is performed, then the resistance to soldering heat test (4.8.5.2) need not be performed.

2/ Test shall not be performed if the manufacturer provides certification that all external materials are fungus resistant.

TABLE H6. Qualification inspection for transformers and inductors similar to transformers and inductors that have been qualified.

Examination or test	Requirement paragraph	Method paragraph
Visual and mechanical examination (external)	3.1, 3.4 to 3.4.4.4 incl., 3.5 to 3.5.2.7 incl., 3.5.3, 3.5.7, 3.11.1 to 3.11.8 incl. 3.32 and 3.33	4.8.1.1
Dielectric withstanding voltage		
At atmospheric pressure	3.12	4.8.8.1
At barometric pressure (when applicable)	3.12	4.8.8.2
Induced voltage	3.13	4.8.9
Insulation resistance	3.14	4.8.10
Electrical characteristics		4.8.11
Polarity	3.15.1	4.8.11.9
Turns ratio	3.15.2	4.8.11.12
DC resistance and resistance unbalance	3.15.3	4.8.11.3
Primary impedance	3.15.4	4.8.11.6
Core loss	3.15.5	4.8.11.14
Insulation power loss	3.15.6	4.8.11.15
Bushings	3.15.7	4.8.11.16
No load	3.15.8	4.8.11.1
Efficiency and regulation	3.15.9	4.8.11.2
Short circuit	3.15.10	4.8.11.13
Inductance and inductance unbalance	3.15.11	4.8.11.4
Harmonic distortion	3.15.12	4.8.11.5
Wave shape	3.15.15	4.8.11.11
Temperature rise	3.16	4.8.11.19
Partial discharge	3.17	4.8.12
Impulse	3.18	4.8.13
Terminals not being tested	3.18.1	4.8.11.17
Electromagnetic compatibility	3.19	4.8.11.8
Overload	3.27	4.8.20
Dielectric withstanding voltage:		
At reduced voltage	3.12	4.8.8.3
Induced voltage	3.13	4.8.9
Insulation resistance	3.14	4.8.10

TABLE H6. Qualification inspection for transformers and inductors similar to transformers and inductors that have been qualified (cont.)

Examination or test	Requirement paragraph	Method paragraph
Corona	3.17	4.8.12
Visual and mechanical examination (external)	3.1, 3.4 to 3.4.4.4 incl., 3.5 to 3.5.2.7 incl., 3.5.3, 3.5.7, 3.32 and 3.33	4.8.1.1

4.5.3 Retention of qualification. To retain qualification, the supplier shall meet the requirements of 4.5.1 every 36 months. The qualifying activity shall be notified in advance before action is initiated for retention of qualification. The test samples shall be selected from items produced within a previous 6-month production period. However, if this production period cannot be met, the qualifying activity shall determine which items are to be selected for qualification inspection. The supplier shall also forward at 12 month intervals to the qualifying activity a summary of the results of the tests performed for inspection of product for delivery, groups A and B, indicating as a minimum the number of lots that have passed and the number that have failed. The results of tests of all reworked lots shall be identified and accounted for.

4.6 First article inspection. This inspection consists of meeting all of the qualification tests of 4.5 through 4.5.1.3 inclusive and table H5. Procuring activities may require contractors to furnish first article samples of these transformer or inductor units that they propose to supply for government inspection and contractual approval. First article approval is valid only on the contract under which it is granted, unless extended by the government to another contract. If a supplier desires to have his first article test data also considered for qualification, he must notify the cognizant government agency immediately upon award of contract and prior to the start of testing (see 6.2).

4.7 Quality conformance inspection.

4.7.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspections. All deliverable high voltage high power transformers and inductors shall be subjected to Group A and B inspections

4.7.1.1 Inspection lot. Inspection shall be for completely assembled transformers or inductors of the same grade, class, family and electrical characteristics, manufactured under essentially the same conditions and having similar construction and materials. (Similar construction and materials shall be construed to include differences that will not affect test results).

4.7.1.2 Group A inspection. Group A inspection shall consist of the examinations and tests specified in table H7 in the order shown.

TABLE H7. Group A inspection

Examination or test	Requirement paragraph	Method paragraph
Visual and mechanical examination (external)	3.1, 3.4 to 3.4.4.4 incl., 3.5 to 3.5.2.7 incl., 3.5.3, 3.5.7, 3.11.1 to 3.11.8 incl. 3.32 and 3.33	4.8.1.1
Seal (grades 4 and 5)	3.11	4.8.7
Dielectric withstanding voltage 1/	3.12	4.8.8.1
Partial Discharge	3.17	4.8.12
Induced voltage	3.13	4.8.9
Insulation resistance	3.14	4.8.10
Electrical characteristics 2/	3.15	4.8.11
DC resistance and resistive unbalance	3.15.3	4.8.11.3
Inductance and inductive unbalance	3.15.11	4.8.11.4
Turns ratio	3.15.2	4.8.11.12
Polarity	3.15.1	4.8.11.9
No load	3.15.8	4.8.11.1

1/ The Government may witness this test prior to performance of group A inspection in which event 4.8.8.3 will apply (see 6.6).

2/ As applicable (see 3.1).

4.7.1.2.1 Group B inspection. Group B inspection shall consist of the tests specified in table H8 in the order shown and shall be made on units which have been subjected to and have passed the group A tests.

TABLE H8. Group B inspection.

Test	Requirement paragraph	Method paragraph
Electrical characteristics: 1/	3.15	4.8.11
Efficiency and regulation at rated load	3.15.9	4.8.11.2
Harmonic distortion	3.15.12	4.8.11.5
Electrostatic shielding	3.19	4.8.11.8.1
Magnetic shielding	3.19	4.8.11.8.2
Storage factor	3.15.14	4.8.11.10
Wave shape	3.15.15	4.8.11.11
Dielectric withstanding voltage at reduced voltage	3.12	4.8.8.3
Partial discharge	3.17	4.8.12

1/ As applicable (see 3.1). The actual circuit may be used for the electrical inspection tests in lieu of the test circuits specified herein.

4.7.1.2.2 Rejected lots. If an inspection article is rejected, the supplier may rework it to correct the defects, or screen out the defective components and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such articles shall be separate from new articles and shall be clearly identified as reinspected articles.

4.7.1.2.3 Disposition of units. Units which have passed all the group B inspection may be delivered on the contract or purchase order, if the units are accepted and are still within specified electrical tolerances, and if the terminals of the sample units are clean and smooth.

4.7.2 Inspection of preparation for delivery. The inspection of the preservation-packaging and interior package marking shall be in accordance with the group A and B quality conformance inspection requirements of MIL-P-116. The inspection of the packing and marking for shipment and storage shall be in accordance with the quality assurance provisions of the applicable container specification and the marking requirements of MIL-STD-129.

4.8 Methods of examination and test.

4.8.1 Visual and mechanical examination.

4.8.1.1 External. Transformers and inductors shall be examined to verify that the materials, external design and construction, physical dimensions, weight, marking and workmanship are in accordance with the applicable requirements (see 3.1, 3.4 to 3.4.4.4 inclusive, 3.5 to 3.5.2.7 inclusive, 3.5.3, 3.5.7, 3.32 and 3.33).

4.8.1.1.1 Post-test. Transformers and inductors shall be examined to verify that the protective coating, filling material and case construction are in accordance with the applicable requirements (see 3.28).

4.8.1.2 Internal. Transformer and inductor inspection covers shall be removed to verify that the materials, internal lead wires, internal mounting, impregnating, potting and workmanship are in accordance with the applicable requirements (see 3.1, 3.4 to 3.4.4.4 inclusive, 3.5.4, 3.5.5 and 3.5.7 and 3.33).

4.8.2 Solderability (see 3.6). Transformers and inductors shall be tested in accordance with 4.8.2.1 or 4.8.2.2, as applicable. The method in 4.8.2.1 is preferred and shall be specified whenever practicable, otherwise the method in 4.8.2.2 shall be used.

4.8.2.1 Solder bath method. Transformers and inductors shall be tested in accordance with method 208 of MIL-STD-202. The following details shall apply:

(a) Special preparation of specimen - Sample components shall not have been soldered during any of the previous tests.
(b) Number of terminations of each part to be tested - A minimum of two of each type of terminal.

4.8.2.2 Soldering iron method. The test shall be performed on solder terminations, attached to the transformer, inductor or auxiliary part thereof. The solder shall conform to type S, composition Sn60, of QQ-S-571. The flux shall conform to type A or W as applicable of MIL-F-14256. The temperature of the bit shall be 300° - 350°C. The iron and solder shall be applied to the termination for 10 seconds. The solder shall be applied for the first 2 seconds. Tinning, as evidenced by the free flowing of the solder with proper wetting of the termination, shall be completed within the first two seconds. The transformer or inductor under test shall remain under standard atmospheric conditions for recovery for fifteen minutes, before final measurements are made.

(a) Special preparation of specimen - The surface shall be smooth and properly tinned and the solder terminations shall not have been soldered during any previous test.

(b) Number of terminations - in accordance with 4.8.2.1.

(c) Examinations of terminations - in accordance with method 208 of MIL-STD-202.

(d) Soldering irons - The soldering iron shall have one of the following bit sizes:

(1) 0.3 inch diameter, 1.25 inch exposed length reduced to a wedge shape, over a length of approximately 0.4 inch.

(2) 0.125 inch diameter, 0.5 inch exposed length, reduced to a wedge shape, over a length of approximately 0.2 inch.

(e) Point of application of soldering iron -1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal, whichever point is closer to the insulating material.

4.8.3 Resistance to solvents (see 3.7). Transformers and inductors shall be tested in accordance with method 215 of MIL-STD-202. The following details shall apply:

(a) The marked portion of the transformer and inductor shall be brushed.

(b) The number of sample units shall be as specified in 4.5.1.1.

(c) Mechanical deformation, corrosion, or etching shall be cause for rejection.

4.8.4 Thermal shock (see 3.8). Transformers and inductors shall be tested in accordance with method 107 of MIL-STD-202. The temperature for step 3 shall be the maximum operating temperature for the class. The following details and exceptions shall apply:

(a) Test condition - A, 10 cycles, for qualification (group III, table H5).

(b) Test condition - A-1 (when specified) for qualification (group II, table H5) and group A (subgroup I).

(c) After cycling - Transformers and inductors shall be examined for evidence of leakage and other visible damage.

4.8.5 Resistance to soldering heat (see 3.9). Transformers and inductors shall be tested in accordance with 4.8.5.1 or 4.8.5.2, as applicable. The method in 4.8.5.1 is preferred and specified whenever practical, otherwise the method in 4.8.5.2 shall be used.

4.8.5.1 Solder bath method. Transformers and inductors shall be tested in accordance with method 210 of MIL-STD-202. The following details shall apply:

(a) Special preparation of specimen - Sample units shall not have been soldered during any of the previous tests.

(b) Depth of immersion in the molten solder - To a point 1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal, whichever point is closer to the insulating material.

(c) Test condition - A (350 $\pm 10^{\circ}C$; immersion, $3^{+1/2}_{-0}$ seconds).

(d) Examination after test - The transformers and inductors shall be visually examined and there shall be no seepage of the impregnant, loosening of the terminals or other mechanical damage. The windings of transformers or inductors shall be checked for continuity.

4.8.5.2 Soldering iron method. The test shall be performed on all solder terminations, attached to the transformer or inductor. The solder shall conform to type S, composition of Sn60 of QQ-S-571. The flux shall conform to type A or W as applicable of MIL-F-14256. The temperature of the bit shall be 300° - $350^{\circ}C$. The iron and solder shall be applied to the termination for 10 seconds. The solder shall be applied for the first 2 seconds. Tinning, as evidenced by the free flowing of the solder with proper wetting of the termination, shall be completed within the first two seconds. The transformer or inductor under test shall remain under standard atmospheric conditions for recovery for fifteen minutes, before final measurements are made.

(a) Special preparation of specimen - The surface shall be smooth and properly tinned and the solder terminations shall not have been soldered during any previous test.

(b) Examinations after test - in accordance with 4.8.5.1.

(c) Soldering irons - The soldering iron shall have one of the following bit sizes:

  (1) 0.3 inch diameter, 1.25 inch exposed length reduced to a wedge shape, over a length of approximately 0.4 inch.

  (2) 0.125 inch diameter, 0.5 inch exposed length reduced to a wedge shape, over a length of approximately 0.2 inch.

(d) Point of application of soldering iron - 1/4 inch from the nearest insulating material or to one-half the exposed length of the terminal whichever point is closer to the insulating material.

4.8.6 Terminal strength (see 3.10). Transformers and inductors shall be tested as specified in 4.8.6.1 to 4.8.6.3.2 inclusive, as applicable. After each test, the terminals shall be examined for loosening and rupturing and other mechanical damage. Unless otherwise specified, all terminals on each test sample shall be subjected to the following tests, up to a maximum of four identical terminals per sample.

4.8.6.1 Pull.

4.8.6.1.1 Solid-wire and insulated wire lead terminals. Transformers and inductors and auxiliary components , such as sensors and motors, shall be tested in accordance with Method 211 of MIL-STD-202. The following details shall apply:

(a) Test condition - A.

(b) Points of measurement - A force shall be applied in the direction of the axis of termination and shall be increased gradually until the magnitude specified in table H9 is reached and shall be maintained for a period of 5 to 10 seconds.

4.8.6.1.2 Solder terminals. Transformers, inductors and auxiliary components shall be tested in accordance with method 211 of MIL-STD-202. The following details shall apply:

(a) Test condition - A.

(b) Points of measurement - A force as specified in table IX shall be applied to each terminal at the point where the lead from the external circuit connects to it. The force shall be applied in the weakest direction of the terminal and shall be increased gradually to the specified magnitude and shall be maintained at that value for a period of 5 to 10 seconds.

TABLE H9. Pull.

Cross-sectional area of electrode at its smallest point at which lead from external circuit connects	Force
Circular mils	Pounds
≤ 2,000 - - - - - - - - - - - - - - - - - -	2.0
> 2,000 - - - - - - - - - - - - - - - - - -	5.0

4.8.6.2 Twist or bend.

4.8.6.2.1 Solid-wire lead terminals (other than printed circuit terminals). Following the test specified in 4.8.6.1.1, transformers and inductors shall be tested in accordance with method 211 of MIL-STD-202. The following detail and exception shall apply:

(a) Test condition - D.

(b) Application of torsion - The body of the component part or the clamped terminal shall be rotated through 360 degrees about the original axis of the bent terminal, in alternating directions, for a total of five rotations, at the rate of approximately 3 seconds per rotation.

4.8.6.2.2 Flat solder terminals. Any terminal that shows permanent deformation greater than 15 degrees of the metal portion of the terminal in the terminal-pull test specified in 4.8.6.1.2 shall be tested in accordance with method 211 of MIL-STD-202. This test does not apply to terminals which show permanent deformation but are not designed to be bent 45 degrees. The following detail and exception shall apply:

(a) Test condition - B.

(b) Number of bending operations - Five times through an angle of 90 degrees (45 degrees each side of center).

4.8.6.3 Torque. Transformers and inductors shall be tested in accordance with method 211 of MIL-STD-202, test condition - E. Torque for 5/16 inch, 3/8 inch and ½ inch screw thread terminals shall be 40, 48 and 64 pound-inches, respectively.

4.8.7 Seal (see 3.11 and 6.15.13). Transformers and inductors shall be tested in accordance with 4.8.7.1, 4.8.7.2, or 4.8.7.3, as applicable. Any transformer or inductor which shows evidence of leakage may be given remedial treatment. After completion of the treatment, the seal test shall be repeated as evidence that such remedial treatment is adequate. All other units in the lot which have been given similar satisfactory remedial treatment shall be acceptable.

4.8.7.1 Liquid-filled units. Transformers and inductors shall be heated in an oven maintained at a temperature equal to or not more than $5^{o}C$ greater than the sum of the specified maximum ambient temperature and the allowable temperature rise (see 3.1 and 6.1.2), for not less than 6 hours.

4.8.7.2 Gas-filled units. Transformers and inductors shall be tested in accordance with method 112 of MIL-STD-202. The following details shall apply:

(a) Test condition letter - C.

(b) Leakage-rate sensitivity - 10^{-6} atm cm^3/s.

(c) Procedure IV, as specified (see 3.1 and 6.1.2), test for gross leaks as specified in 4.8.7.3.

4.8.7.3 Auxiliary components. Auxiliary components include pressure and temperature transducers, fans, pumps and controls.

4.8.7.3.1 Transducers. Pressure-vacuum transducer and liquid temperature transducers shall be tested at least three times during qualification. No damage to the transformer or sensor shall result from these tests.

4.8.7.3.2 Motors. Fan, pump and control motors shall be tested for electrical continuity. Fan and pump motors shall function, without failure, during the life test.

4.8.7.3.3 Surge Arrestors. Surge arrestors shall be disconnected during impulse testing and dielectric withstanding voltage tests. Surge arrestors shall be tested by applying an impulse 110% greater than the design surge voltage. The surge arrestor shall operate successfully for three consecutive impulses.

4.8.8 Dielectric withstanding voltage (see 3.12 and 6.14). Transformers and inductors shall be tested in accordance with 4.8.8.1 and 4.8.8.2 when applicable.

4.8.8.1 At atmospheric pressure. Transformers and inductors shall be tested in accordance with method 301 of MIL-STD-202. The following details and exceptions shall apply:

(a) Magnitude of test voltage shall be 160% working voltage.

(1) Winding-to winding - Winding to winding voltage shall be calculated. The test voltage shall not exceed 160% peak working voltage.

(2) Winding-to-shield/ground - The winding to shield/ground voltage shall be calculated. Test voltage shall be 160% maximum calculated voltage. Test voltages shall be applied gradually at a rate not exceeding 500 volts rms per second.

(b) Nature of potential - AC.

(c) Duration of application of specified test voltage - 60 $^{+}_{-}5$ seconds for quality conformance inspection, 60 $\pm$ 5 seconds for qualification inspection.

(d) Points of application of test voltage:

(1) Winding to case or core - Between each winding and the case or core with all windings not under test grounded to the case (if cased) or to the normal mounting means (if uncased) and to the core (if accessible). (See 6.18.)

(2) Between windings - The voltage shall be applied between each winding and each of the other windings with all windings not under test grounded to the case (if cased) or to the normal mounting means (if uncased) and to the core (if accessible). These tests need not be made if the winding-to-case or-core test voltage of either winding under consideration is equal to, or greater than, the winding-to-winding test voltage. The method used to perform the between-windings dielectric-withstanding voltage test shall consist of one source of test voltage, so that the winding-to-winding test voltage shall be according to (a). One terminal of the source shall be grounded to the case (if cased), or the normal mounting means (if uncased), and to the core (if accessible). The test voltage applied shall not exceed the test voltage required for each of the windings to ground, and shall be applied so that the required test voltage appears between the windings. Multiple-section windings designed for operation only in series or parallel shall be considered as a single winding. In no case shall the test voltage applied between the windings exceed the sum of the test voltage for each of these windings to the case (if cased) or to the normal mounting means (if uncased), and to the core (if accessible).

(e) The high voltage source shall have a minimum of 5 kilovolt-amperes capacity.

(f) Examination during and after test - Transformers and inductors shall be examined for evidence of arcing, flashover, breakdown of insulation, and damage.

4.8.8.1.1 For special designs. Transformer windings internally grounded or having any part of the winding designed for operation at or near ground potential shall be subjected to the induced-voltage test or a combination of the dc dielectric-withstanding voltage on the low-voltage terminal together with induced voltage, as applicable (see 4.8.9). Windings with special dielectric features (e.g., graded insulation) shall be subjected to the test voltage specified (see 3.1 and 6.1.2), or to the induced-voltage test (see 4.8.9). Dielectric-withstanding voltage tests for pulse transformers shall be as specified (see 3.1 and 6.1.2).

4.8.8.2 Altitude. Transformers and inductors designed for operation above 10,000 feet shall be tested as specified in 4.8.8.1 and in accordance with method 105 of MIL-STD-202. The following detail and exceptions shall apply:

(a) Test condition or altitude in feet if below 30,000 feet - As specified (see 3.1 and 6.1.2).
(b) Magnitude of test voltage shall be 160% working voltage.
(c) Examination during and after test - Transformers and inductors shall be examined for evidence of arcing, flashover, breakdown of insulation and damage.

4.8.8.3 At reduced voltage. Transformers and inductors shall be subjected to the dielectric-withstanding voltage tests specified in 4.8.8.1, except that the test voltages shall be 125% percent of the working voltage and shall be applied for a period of 60 seconds.

4.8.9 Induced voltage (see 3.10). Transformers and inductors shall be subjected to the tests specified in 4.8.9.1 through 4.8.9.3 as applicable (see 6.7). During this test, the transformers and inductors shall be examined for evidence of continuous arcing, breakdown of insulation and abrupt changes in the input current. Means shall be provided to indicate fluctuations of input current.

4.8.9.1 All transformers and inductors (see 3.1 and 6.1.2). Transformers and inductors shall be subjected to a voltage sufficient to cause 140 percent the rated voltage to appear across any winding. The test voltage shall be applied to any winding. Windings should be grounded as they would be in service. The test frequency shall be as selected by the manufacturer and shall be remote from any resonant frequency. The test potential shall be applied for 7,200 $\pm$200 cycles, or 5 $\pm$1/2 seconds, whichever is greater.

4.8.9.2 Pulse transformers and inductors. A test pulse voltage shall be applied for 1 minute to any winding at the specified rated repetition rate (see 3.1 and 6.1.2) sufficient to induce a voltage across any winding between 25 and 50 percent of the rated pulse width, in accordance with table H10, and shall be performed in air. This test shall be repeated for units rated at greater than 10,000 volts at 160 percent rated voltage with the transformer or inductor terminals under oil. At the option of the manufacturer, the test in air for transformers and inductors may be made at 160 percent the rated voltage, in which case the second test under oil will not be required. During the test, the transformer and inductor shall be loaded as specified and fitted with specified protective devices (see 3.1 and 6.1.2). The operation of any specified protective device shall not be a cause for failure.

TABLE H10. Induced voltage for pulse transformers and inductors

Max voltage rating on highest voltage winding	Induced voltage
$<$ 10,000	1.6 x rated voltage
$>$ 10,000 to 20,000 incl	1.6 x rated voltage
$>$ 20,000 to 35,500 incl	1.4 x rated voltage

4.8.9.3 Saturating core power transformers. Saturating core power transformers should be tested at the limit of their linear characteristics, using sine wave power sources at 140 percent normal operating frequency. The test voltage shall be applied to any winding sufficient to cause 140 percent the normal peak-to-peak voltage appear across any winding.

4.8.10 Insulation resistance (see 3.14). Transformers and inductors shall be tested in accordance with method 302 of MIL-STD-202. The following details and exceptions shall apply:

(a) Test condition - B for qualification inspection; and dc test potentials from 500 volts to 10,000 volts for quality conformance inspection. However, for quality conformance inspection, rejection shall be based on measurements made at 500 volts.

(b) Points of measurement:

(1) Winding to case or core - The potential shall be applied between each winding and the case or core with all windings not under test grounded to the case.

(2) Between windings - The potential shall be applied between each winding and all other windings connected together.

The measurements shall be made at any temperature above $20^{o}C$ and at ambient room humidity, but rejections shall be based on measurements made at $25^{o}\ {}^{+10^{o}}_{-5^{o}}$ C and at a relative humidity not greater than 80 percent.

4.8.11 Electrical characteristics (see 3.15). The electrical characteristics shall be determined by the tests specified herein, as applicable (see 3.1, 6.1 and 6.1.2). Electrical tests included herein do not embrace all of the electrical tests that may be requested.

4.8.11.1 No load. Rated voltage at the frequency or frequencies specified (see 3.1 and 6.1.2) shall be applied to the primary with the secondary or secondaries unloaded (windings shall not float). The following shall be determined:

(a) No-load rms current (I_{nl}).
(b) No-load power (P_{nl}).
(c) Primary tap and secondary rms voltages.
(d) Center-tap voltage unbalance in percent = $\frac{(V_1 - V_2)}{V_1} \times 100$

The voltage unbalance shall be computed: V_1 and V_2 are the voltages of each part of the winding, and $V_1 \geq V_2$.

4.8.11.2 Efficiency and Regulation

4.8.11.2.1 Unrectified outputs. Unrectified output secondary voltages shall be measured with the transformer primary excited with rated voltage at the specified frequency (see 3.1 and 6.1.2), and with rated rms load currents flowing in the secondary windings.

4.8.11.2.2 Rectified outputs. Rms voltages at the secondary terminals shall be measured with the transformer primary excited at rated voltage at the specified frequency, and with rated dc current flowing from a specified rectifier and filter into a resistive load (see 3.1 and 6.1.2).

4.8.11.2.3 Efficiency. Input power and output power shall be measured with the transformer primary excited at rated voltage at the specified frequency and with rated currents flowing in the secondary windings. Measurements shall be taken at ½ rated output load, rated load and 1.25 rated load at unity power factor. Efficiency shall be calculated using the formula:

$$\text{Efficiency} = \frac{\text{output (watts)}}{\text{input (watts)}} = \frac{\text{input - losses}}{\text{input}} = \frac{\text{output}}{\text{Output + losses}}$$

4.8.11.2.4 Regulation. Regulation shall be determined by measurement or calculation.

4.8.11.2.4.1 Measurement. Secondary voltages shall be measured with the primary fully excited with rated voltage at the specified frequency. Primary and secondary voltage measurements shall be taken at no load and at rated load with unity power factor, 0.8 lagging power factor, and 0.9 leading power factor. Regulation shall be determined by the formula:

$$\text{Regulation} = \frac{V_N - V_L}{V_N}$$

Note: V_N where: V_N = no load, secondary output voltage

V_L V_L = rated load, secondary output voltage

4.8.11.2.4.2 Determination of Transformer Regulation. The regulation of a transformer shall be determined by calculation based on the measured values of impedance voltage and impedance power corrected to the winding maximum operating temperature rise.

The exact regulation is given by:

$$\sqrt{(r + p)^2 + (x + q)^2} - 1 \quad \text{for lagging loads}$$

$$\sqrt{(r + p)^2 + (x - q)^2} - 1 \quad \text{for leading loads}$$

where

p = power factor of load

$q = +\sqrt{1 - p^2}$

x = leakage reactance of transformer

r = dc resistance of transformer windings

The quantities p and q, x, and r are on a per unit basis so that the result is to be multiplied by 100 to get the regulation in percent.

The approximate regulation is given by:

$$pr + qx + \frac{(px - qr)^2}{2} \quad \text{for lagging loads}$$

$$pr - qx + \frac{(px + qr)^2}{2} \quad \text{for leading loads}$$

The terms are on a per-unit basis as indicated above, and the result is to be multiplied by 100 to express the regulation in percent.

This approximation gives results very close to the exact method.

A general expression for the calculation of transformer regulation which permits calculations to any degree of precision justified by the supporting data is:

$$reg = a - \tfrac{1}{2} a^2 + \tfrac{1}{2} a^3 - 5/8\, a^4 + 7/8\, a^5 - \frac{21}{16} a^6 + \frac{33}{16} a^7$$

where

reg = regulation on a per-unit basis

a = a quantity depending upon the angle and magnitude of the transformer impedance, the power factor of the load, and the number of windings in the transformer

4.8.11.2.4.3 <u>Two-Winding Transformers</u>. The quantity a for use in Equation for the calculation of the per-unit regulation of a two-winding transformer is determined as follows:

$$a = z \cos(\phi + \theta) + \frac{z^2}{2}$$

where

$$r = \text{resistance factor} = \frac{\text{impedance loss (in kilowatts)}}{\text{rated kVA}}$$

$$z = \text{impedance} = \frac{\text{impedance kVA}}{\text{rated kVA}}$$

$$x = \text{reactance} = +\sqrt{z^2 - r^2}$$

ϕ = impedance angle of transformer impedance

$$\cos \phi = \frac{r}{z}$$

p = power factor of load = $\cos \theta$

θ = phase angle of load current
positive for leading current
negative for lagging current

4.8.11.2.4.4 <u>Three-Winding Transformers</u>. Unless some simplifying assumptions are made, it is extremely difficult to calculate the regulation of a three-winding transformer. The following assumptions are made:

(1) The current in the secondary winding not being considered shall be assumed as remaining constant even though its voltage actually does change.

(2) The phase angle of the currents in both secondaries shall be taken as given in reference to the voltage of the secondary winding being considered.

In the calculation of the regulation of a three-winding transformer it is customary to utilize the equivalent impedance of each individual winding.

The mutual impedance between the secondary and tertiary windings is the same in magnitude and phase angle as the individual equivalent impedance of the primary winding, as determined by use of Equations in 4.8.11.2.4.2.

The regulation is calculated from the primary winding to each of the secondary windings separately.

The quantity a for use in the Equation of 4.8.11.2.4.2 for the calculation of the per-unit regulation of a three-winding transformer is determined as follows:

(1) For the per-unit regulation from primary to secondary, $a = a_{12}$

$$a_{12} = z_{12} \cos (\emptyset_{12} + \theta_s) + \frac{z_{12}^2}{2} - m_t \cos (\emptyset_m + \theta_t) + \frac{m_t^2}{2}$$

$$+ z_{12} m_t \cos (\emptyset_{12} + \theta_s - \emptyset_m - \theta_t)$$

where

z_{12} = per-unit impedance factor, primary to secondary winding, on basis of secondary load

ϕ_{12} = impedance angle of primary to secondary impedance, z_{12}

θ_s = phase angle of secondary load current
positive for leading current
negative for lagging current

m_t = per-unit mutual impedance factor, tertiary to secondary winding, on basis of tertiary load current

ϕ_m = impedance angle of mutual impedance, tertiary to secondary, m_t

Q_t = phase angle of tertiary load current; positive for leading current; negative for lagging current

4.8.11.3 DC resistance and resistive unbalance. The dc resistance of the windings shall be measured at or corrected to 20^{o} C. The resistive unbalance of center-tapped windings in percent $\frac{(R_1 - R_2)}{R_1}$ x 100 shall be computed. R_1 and R_2 are the resistances of each part of the winding, and $R_1 \geq R_2$. For resistances under 1 ohm, measurements shall be made with a Kelvin bridge or equivalent.

4.8.11.4 Inductance and inductive unbalance. The inductance of the windings shall be measured at the specified test voltage and frequency with the specified dc current applied (see 3.1 and 6.1.2). The inductive unbalance of center-tapped windings in percent $\frac{(L_1 - L_2)}{L_1}$ x 100 shall be computed. L_1 and L_2 are inductances of each part of the winding, and $L_1 \geq L_2$.

4.8.11.5 Harmonic distortion. The transformer shall be terminated in its proper source and load impedance. A sine-wave voltage of specified frequency shall be applied such that the specified output conditions are achieved and the total harmonic distortion shall then be computed or measured (see 3.1 and 6.1.2).

4.8.11.6 Primary impedance (for qualification and first article inspection only). Transformer primary impedance shall be measured with all normally loaded secondaries loaded with their specified impedances, and with specified dc currents flowing in the windings. The resistance and reactance looking into the primary shall be measured at the specified input frequency and voltage by a bridge or equivalent method approved by the Government (see 3.1).

4.8.11.7 Self-resonant frequency (SRF). Unless otherwise specified (see 3.1 and 6.1.2), the self-resonant frequency shall be determined as follows, using the test circuit shown on Figure H2. Starting at the lowest frequency within the specified frequency range, the frequency shall be increased and the voltmeter or equivalent observed for voltage dip. The frequency at which the minimum dip occurs shall be recorded as the self-resonant frequency.

4.8.11.8 Electromagnetic compatibility. Electromagnetic compatibility shall be determined by measuring the electrostatic and electromagnetic shielding effectiveness in accordance with MIL STD 461.

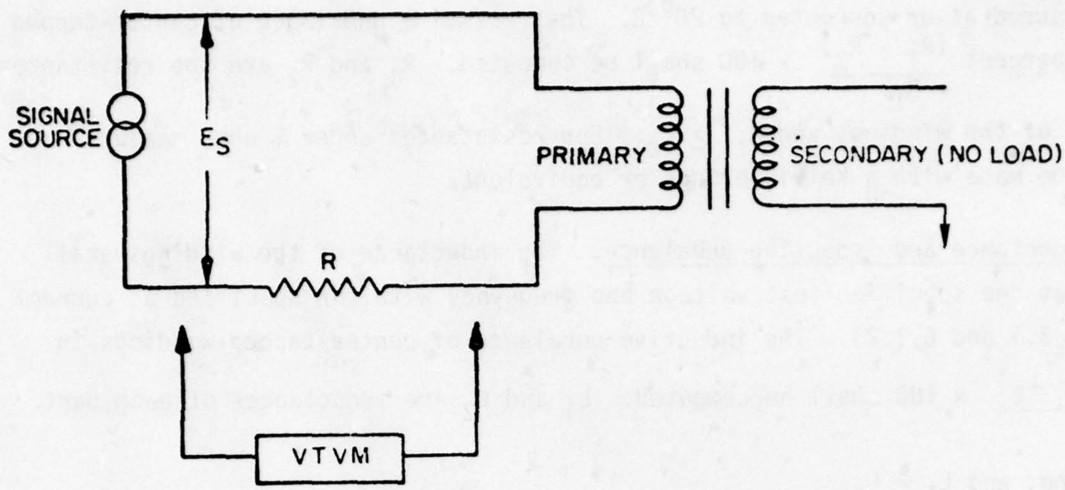


FIGURE H2 Measurement of SRF.

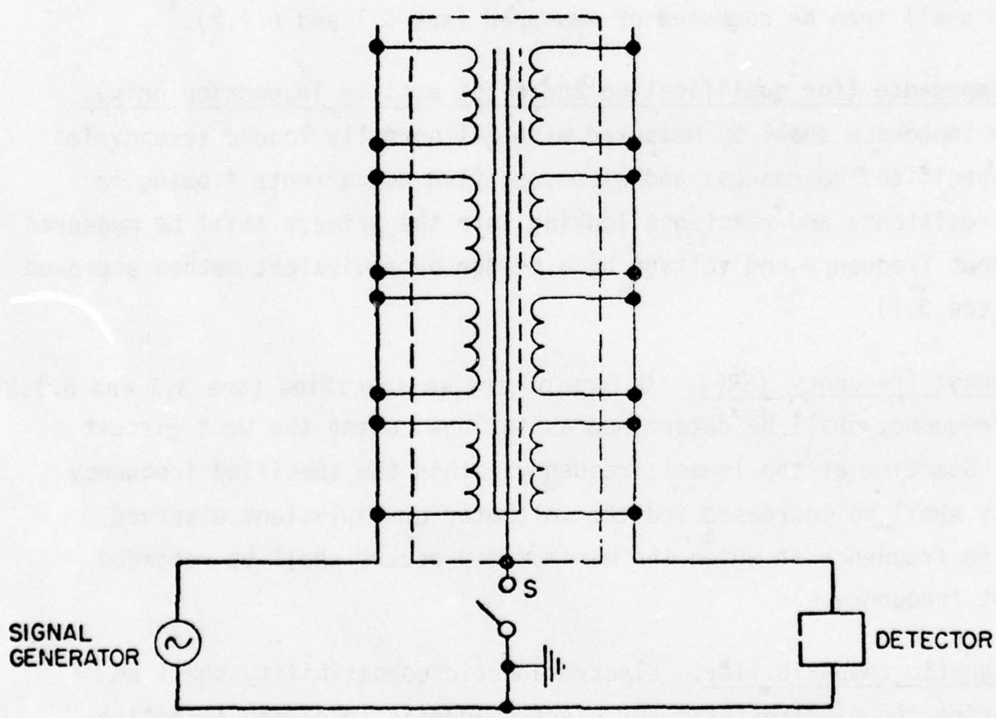


FIGURE H3 Electrostatic-shielding circuit.

4.8.11.8.1 Electrostatic shielding. With all windings short-circuited and those on the same side of the electrostatic shield connected together, using the circuit shown on Figure H3, the voltage of the signal generator at the specified frequency (see 3.1 and 6.1.2) shall be set to give a definite indication on the detector, with switch "S" open. With switch "S" closed, the generator voltage shall be increased so as to yield the same indication on the detector, and the ratio of the generator voltages shall be computed. The detector shall have a minimum input impedance of 1 megohm.

4.8.11.8.2 Magnetic shielding. The transformer or inductor shall be placed in the approximate center of a Helmholtz structure (see 6.8), consisting of two test coils placed coaxially 1 foot apart and connected in series aiding, but at least 3 inches from the transformer envelope. Each coil shall consist of 1,500 turns of 0.00795-inch diameter (AWG size 32) wire, wound on a coil form having a radius of 1 foot and a length of 1 inch. A 115-volt, 60 Hz alternating voltage shall be applied across the series-connected coils; the transformer or inductor shall be rotated until the voltage across the highest voltage or highest impedance winding is a maximum, and this value shall be noted. The detector shall have a minimum impedance of 1 megohm.

4.8.11.8.3 Alternate test. The specimen under test shall be energized and the external field shall be measured by a suitable probe.

4.8.11.9 Polarity. With the transformer primary and secondary windings connected in series as specified (see 3.1 and 6.1.2), and with a voltage applied to one of the windings, comparison shall be made between the sum of the voltages across individual windings and the voltage across the series of windings. Any other suitable method of determining polarity is permissible.

4.8.11.9.1 Alternate methods. Two alternate methods are in common use for testing the polarity and checking the lead marking. They are: 1) inductive kick with direct current, and 2) alternating-voltage test.

4.8.11.9.2 Polarity by Inductive Kick. Polarity of transformers with leads arranged as in Figures H4-1 or H4-2 may be determined at the time of making the resistance measurements as follows:

(1) With direct current passing through the high-voltage winding, connect a high-voltage, dc voltmeter across the outlet terminals of the same windings so as to get a small positive deflection of the pointer.

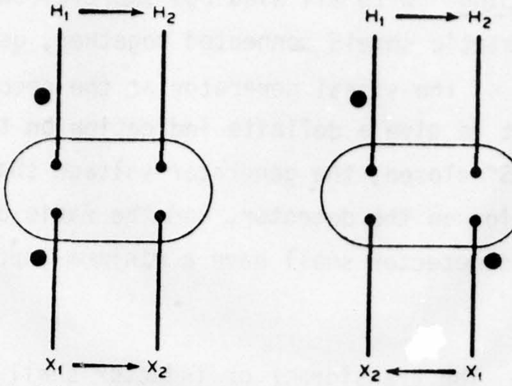


Fig. H4-1
Subtractive Polarity

Fig. H4-2
Additive Polarity

Leads

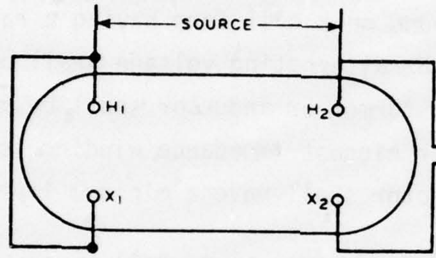


Fig. H5
Polarity by Alternating-Voltage Test

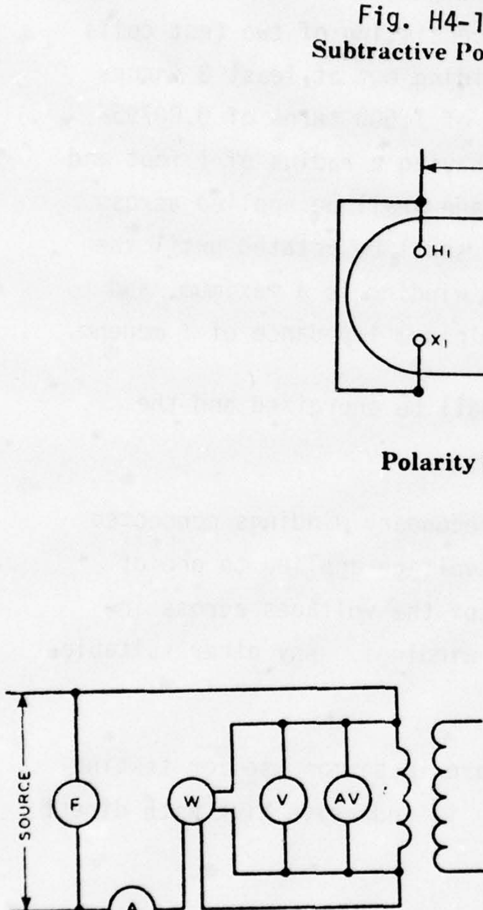


Fig. H6-1
Without Instrument Transformers

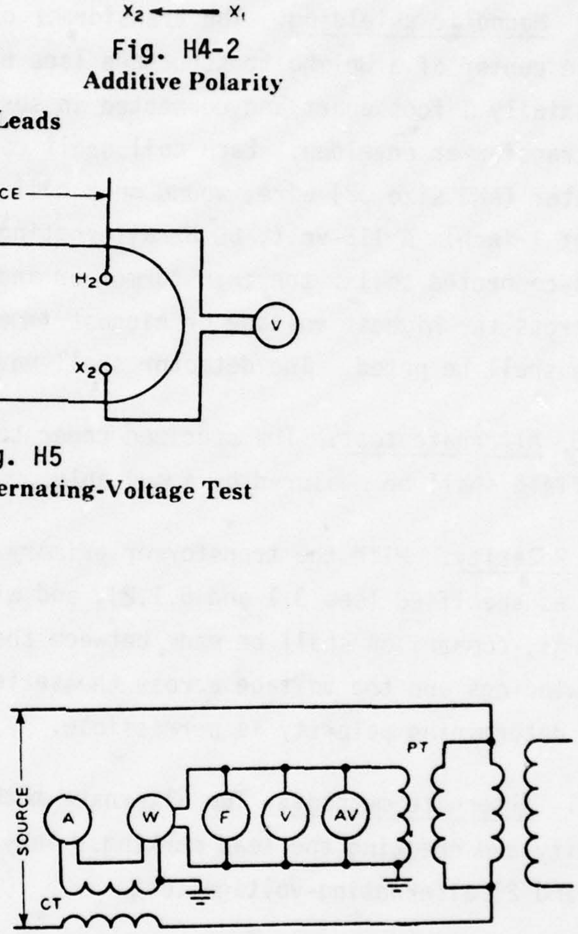


Fig. H6-2
With Instrument Transformers

Fig. H-6

Connections for the Excitation Test of a Single-Phase Transformer

AV Average-Voltage Voltmeter

(2) Then transfer the two voltmeter leads directly across the transformer to the adjacent low-voltage leads, respectively.

(3) The direct-current excitation is then broken, thereby inducing a voltage in the low-voltage winding (inductive kick) which will cause a deflection in the voltmeter.

(4) If the pointer swings in the same direction as before (positive), the polarity is additive.

(5) If the pointer swings in a negative direction, the polarity is subtractive.

4.8.11.9.3 Polarity by Alternating-Voltage Test. Connect the adjacent left-hand high-voltage and low-voltage outlet leads together facing the low-voltage side of the transformers (such as H_1 and X_1 in Figure H5).

Apply any convenient value of alternating voltage to the full high-voltage winding and take readings of the applied voltage and the voltage between the right-hand adjacent high-voltage and low-voltage leads.

If the latter reading is greater than the former, the polarity is additive.

If the latter voltage reading is less than the former (indicating the approximate difference in voltage between that of the high-voltage and low-voltage windings), the polarity is subtractive.

This method is practically limited to transformers in which the ratio of transformation is 30 to 1, or less, since otherwise the difference between the two readings will not be very marked.

4.8.11.9.4 Polarity Test on Three-Phase Transformer. A phase-relationship for three-phase units shall be determined.

4.8.11.10 Storage factor. Storage factor (Q) shall be measured under the conditions specified (see 3.1 and 6.1.2).

4.8.11.11 Wave shape. With the source and load conditions as specified (see 3.1 and 6.1.2), the wave shape of the output shall be determined.

4.8.11.12 Turns ratio or voltage ratio (as specified). The ratio shall be determined by the voltmeter method or any other suitable means.

4.8.11.13 Short-circuit test (for qualification or first article inspection only). With the secondary windings shorted in turn, the voltage applied to the primary shall be adjusted until the secondary is carrying rated current. The primary power in watts shall then be measured.

4.8.11.13.1 Overload short circuit. With all secondary windings short circuited, the voltage applied to the primary shall be adjusted until the high power secondary winding is carrying 3 per unit rated current for 1 second. The transformer shall not fail.

4.8.11.14 Core Loss. The core loss or excitation loss shall be determined with a sine wave voltage, unless a different wave form is inherent in the operation of the transformer. The average absolute voltage reading voltmeter shall be used for correcting the measured excitation losses to a sine-wave voltage basis. The average -voltage voltmeter method, therefore, utilizes an average-voltage indicating voltmeter consisting of a d'Arsonval voltmeter having in series with itself a full-wave rectifier.

Figure H6-1 shows the necessary equipment and connections when no instrument transformers are needed; Figure H6-2, when they are needed, which is the general case. As indicated in Figure H6-1, the voltmeter should be connected nearest to the load, the ammeter nearest to the supply, and the wattmeter between the two with its potential coil on the load side of the current coil.

When transformers are used for measuring excitation losses, they shall be instrument transformers.

Low power-factor wattmeters shall be used to obtain accurate results.

Either the high- or low-voltage winding of the transformer under test may be used, but it is generally more convenient to make this test using the low-voltage winding. The full winding (not merely a portion of the winding) shall be used.

Adjust the frequency to the desired value as indicated by the frequency meter, and the voltage to the desired value by the average-voltage voltmeter. Record the simultaneous values of frequency, rms voltage, power, average-voltage and current readings. Then disconnect the transformer under test and read the tare on the wattmeter which represents the losses of the connected instruments (and potential transformer if used), and which is to be subtracted from the earlier wattmeter reading to obtain the excitation loss of the transformer under test.

The eddy-current loss in the core varies with the square of the rms value of the excitation voltage. When the test voltage is held at rated voltage with the average-voltage voltmeter, the actual rms value of the test voltage may not be the rated value, and the eddy-current loss in the test will be related to the correct eddy-current loss at rated voltage by Equation 1b.

The correct total excitation loss of the transformer shall be determined from the measured value by means of equation 1a:

$$P = \frac{P_m}{P_1 + kP_2} \qquad \text{(Eq 1a)}$$

where

P = excitation loss at voltage E_a, corrected to a sine-wave basis

P_m = excitation loss measured in test

P_1 = per unit hysteresis loss, referred to P_m

P_2 = per unit eddy-current loss, referred to P_m

$$k = \left(\frac{E_r}{E_a}\right)^2 \qquad \text{(Eq 1b)}$$

E_r = test voltage measured by rms voltmeter

E_a = equivalent sine-wave voltage, rms measured by average-voltage voltmeter.

4.8.11.14.1 Excitation Loss of Three-Phase Transformers. The methods described above for single-phase units shall apply also to three-phase units, with the following additions and modifications:

(1) In measuring the core loss of three-phase transformers with two wattmeters, three entirely separate sets of readings shall be taken by using each of the three lines in succession as the common line. The average value of the three sets of readings shall be recorded as the true no-load loss.

(2) In using the two wattmeter method the wattmeters must be read accurately. Because of the low power factor, the reading of one wattmeter will be negative and must be subtracted from the other. The two readings may be of the same general order of magnitude, so that slight inaccuracies in their values may lead to large percentage errors in their small difference. Under such difficult conditions greater accuracy may be obtained by the following alternative procedure.

(3) Measurements may be made with three wattmeters, each potential circuit being connected from one line to the three-phase neutral, when available. The three readings are added to obtain the excitation loss.

(4) If the three-phase neutral is not available, an artifical neutral may be derived. If potential transformers are necessary, the open Δ connection should be used to supply the Y-connected wattmeters.

4.8.11.15 Insulation Power Loss. The dc insulation power loss shall be calculated using values obtained in 4.8.10 Power shall be calculated by proportioning the dc test voltage to the rated voltage of the windings.

4.8.11.16 Bushings. The insulation level of bushings shall be twice rated voltage. Bushings shall be given dielectric withstanding voltage tests and impulse tests.

4.8.11.17 Terminals not being tested. Terminals and auxiliary wiring not being tested shall be grounded or short circuited in a manner that does not interfere with the test article or generate excessive voltages within the non-tested circuit.

4.8.11.18 Altitude. Transformers and inductors housed in metal, sealed, pressurized or liquid filled cases having coaxial shielded output leads or sealed coaxial shielded leads are exempt from altitude tests.

4.8.11.19 Temperature rise (see 3.16). Unless otherwise specified (see 3.1 and 6.1.2), the temperature-rise test shall be performed on transformers and on inductors. The temperature rise of each winding shall be based on the change-in-resistance method and shall be computed by the following formula:

$$T = \frac{R-r}{r}(t + 234.5) - (T-t)$$

Where

T = Temperature rise (in ^{O}C) above specified maximum ambient temperature (see 3.1 and 6.1.2).
R = Resistance of winding (in ohms) at temperature ($T + \Delta T$).
r = Resistance of winding (in ohms) at temperature (t).
t = Specified initial ambient temperature (in ^{O}C).
T = Maximum ambient temperature in ^{O}C) at time of power shutoff. (T) shall not differ from (t) by more than 5^{O}C.

At least three potential hot spots in the transformer or inductor shall be measured. The transformers shall be conditioned for at least 2 hours prior to test with the normal cooling systems operating before resistance (r) is measured. For transformers, rated voltage shall be applied to the primary with the specified loads across the secondaries (see 3.1 and 6.1.2). For inductors, rated dc and ac current shall be applied to the windings. Transformers or inductors shall be operated until two consecutive resistance readings on the highest resistance winding are the same. If the coolant power is required to be shut off, the resistance measurements (R) shall be made as soon as possible. The transformers and inductors shall then be examined for evidence of physical damage. At the option of the supplier, the test may be performed at 60 Hz for transformers rated at 50/60 Hz provided that the primary voltage is increased to 1.2 times the rated voltage and the secondary currents are maintained at rated current.

4.8.12 Partial discharges (see 3.17) When specified (see 3.1 and 6.1.2, transformers and inductors shall be tested in accordance with 4.8.12.1 or 4.8.12.2 as applicable. The detector used for this test shall have the sensitivity of one picocoulomb or less and shall have a reasonably uniform response up to 500 kilohertz. A liquid-filled unit may be tested at any angle of inclination unless an angle is specified (see 3.1 and 6.1.2). Partial discharge peak magnitudes shall be less than 100 picocoulombs for a 10-minute test at rated voltage.

4.8.12.1 Intrawinding insulation. When specified (see 3.1 and 6.1.2), transformers and inductors shall be tested using circuit 1 of figure H7. The corona peak test voltage shall be applied under pressures equivalent to pressures ranging from sea level to the altitude specified (see 3.1 and 6.1.2). Partial discharge peak magnitudes shall be of less than 50 picocoulombs during a 10 minute test at normal operating voltage. High voltage winding shall have a ground reference.

4.8.12.2 Interwinding insulation. When specified (see 3.1 and 6.1.2), transformers and inductors shall be tested using circuit 2 or 3 of figure H7, as applicable. The test voltages shall be applied under pressures equivalent to pressures ranging from sea level to the altitude specified (see 3.1 and 6.1.2), in the same manner as specified for the dielectric-withstanding voltage test (see 4.8.5). Continuous partial discharges of 5 picocoulombs (PC) are acceptable . Peak discharges above 100 PC during a 10-minute test at normal operating voltage are unacceptable.

4.8.13 Impulse. When impulse tests on line terminals are specified (see 3.1 and 6.1.2), they shall consist of and be applied in the following order: one reduced full wave, two chopped-waves and one full wave in accordance with NEHA Pub. N0109 and ASTM D1686.

4.8.13.1 Reduced Full-Wave Test. For this test the applied voltage wave shall have a crest value of between 50 and 70 percent of the full-wave value given in Tables 4 or 5 of American National Standard C57.12.00-1973 (IEEE Std 462-1973).

4.8.13.2 Chopped-Wave Test. For this test the applied voltage wave shall be chopped by a suitable air gap. It shall have a crest value and time to flashover in accordance with Tables 4 or 5 of American National Standard C57.12.00-1973 (IEEE Std 462-1973). This gap shall be located as close as possible to the terminals, and the impedance shall be limited to that of the necessary leads to the gap.

4.8.13.3 Front-of-Wave Test. For this test the voltage shall be chopped on the rising front before the normal crest of the wave by a suitable air gap. It shall have a crest value and time to flashover in accordance with Table 10 of American National Standard C57.12.00-1973 (IEEE Std 462-1973).

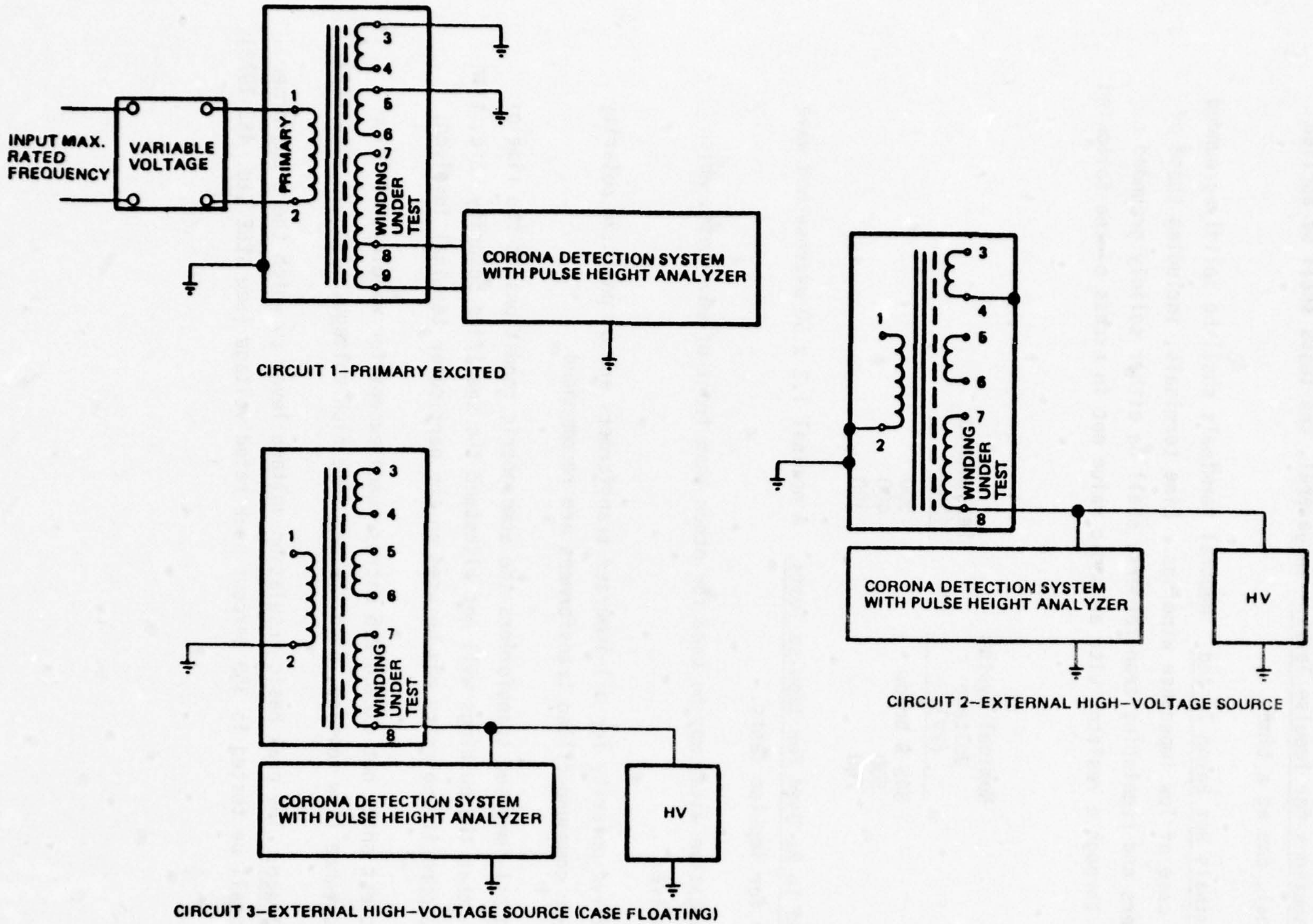


Figure H7: Corona Test Circuits

4.8.13.4 Connections for Impulse Tests. In general, the tests shall be applied to each terminal, one at a time.

4.8.13.5 Terminals Not Being Tested. Neutral terminals shall be solidly grounded except in the case of low impedance windings. Line terminals, including those of autotransformers and regulating transformers, shall be either solidly grounded or else grounded through a resistor with an ohmic value not in excess of the following values:[1]

Nominal System Voltage (kV)	Resistance (Ohms)
345 & below	500
500	400
700	300

4.8.13.6 Wave To Be Used for Impulse Tests. A nominal 1.2 x 50 microsecond wave shall be used for impulse tests.

Positive or negative waves may be used for other than front-of-wave test, which shall be negative.

Waves of negative polarity for oil-immersed transformers and of positive polarity for dry-type or compound-filled transformers are recommended.

If in testing oil-immersed transformers the atmospheric conditions at the time of test are such that the bushings will not withstand the specified polarity wave, then a wave of the opposite polarity may be used on the particular terminal involved.

The time to crest shall not exceed 2.5 microseconds except for windings of large impulse capacitance (low voltage, high kVA and some high voltage, high kVA windings).

4.8.13.7 Voltage. The peak basic insulation voltage level to which the transformer or inductor shall be tested is 350 percent peak rated voltage (See IEEE Std. 462-1973).

4.8.14 <u>Salt spray (corrosion) (see 3.21). When specified (see 3.1 and 6.1.2.)</u> Transformers or inductors shall be tested in accordance with method 101 of MIL-STD-202.

(a) Test condition - B.

(b) Salt solution concentration - 5 percent.

(c) Examination after exposure - Transformers and inductors shall be thoroughly washed. The temperature shall not exceed 38°C. The transformer or inductor shall be placed in an oven maintained at 50° $\pm$3°C for a period of 24 $\pm$4 hours. At the end of this period, the transformers and inductors shall be removed from the oven and examined for corrosion.

4.8.15 <u>Vibration (see 3.22)</u>. Transformers and inductors shall be tested in accordance with 4.8.15.1 or 4.8.15.2, as applicable.

4.8.15.1 <u>Vibration, low frequency</u>. Transformers and inductors shall be tested in accordance with method 201 of MIL-STD-202. The following details and exceptions shall apply:

(a) Tests and measurements prior to vibration - Not applicable.

(b) Method of mounting - Transformers and inductors shall be rigidly mounted by their normal mounting means.

(c) Procedure - When specified (see 3.1 and 6.1.2), transformers and inductors shall be placed in a test chamber and preheated to the specified maximum ambient temperature for the class (see 3.1 and 6.1.2) plus one-half the allowable temperature rise. Vibration in each plane shall begin 5 minutes after removal from the test chamber.

(d) Apparatus - For transformers and inductors weighing more than 10 pounds, the sequence of vibration shall be as follows: First vertically, and then horizontally in two mutually perpendicular directions. Two machines may be used (one vibrating horizontally and one vibrating vertically), or a single machine may be used which provides for both vertical and horizontal table motion, or a vertical vibrating machine, at the option of the supplier.

(e) Examinations after vibration - Transformers and inductors shall be examined for evidence of leakage and physical damage.

4.8.15.2 <u>Vibration, high frequency (when specified)</u>. Transformers and inductors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exception shall apply:

(a) Mounting of specimens - As specified in 4.8.15.1(b).

(b) Test-condition - D, unless otherwise specified.

(c) Examinations after vibration - As specified in 4.8.15.1(e).

4.8.16 Shock (see 3.23). Transformers and inductors shall be tested in accordance with 4.8.16.1, or when specified (see 3.1 and 6.1.2), in accordance with 4.8.16.2.

4.8.16.1 Specified pulse. Transformers and inductors shall be tested in accordance with method 213 of MIL-STD-202. The following details and exceptions shall apply:

(a) Test condition - I, unless otherwise specified.

(b) Examinations after shock - Transformers and inductors shall be examined for evidence of leakage and physical damage.

4.8.16.2 High-impact. Transformers and inductors shall be tested in accordance with method 207 of MIL-STD-202. The following detail and exception shall apply:

(a) Mounting fixtures - Figure "Standard mounting fixtures for electrical controller parts" of method 207.

(b) Examinations after shock - As specified in 4.8.16.1(b).

4.8.17 Winding continuity (see 3.24.) All windings of transformers and inductors shall be tested for electrical continuity by any suitable means.

4.8.18 Immersion (see 3.25). Transformers and inductors shall be tested in accordance with method 104 of MIL-STD-202. The following detail and exception shall apply:

(a) Test condition - B.

(b) After final cycle - Transformers and inductors shall be washed under running tap water and dried. After the drying period, transformers and inductors shall be examined for evidence of leakage and other visible damage.

4.8.19 Moisture resistance (see 3.26). Transformers and inductors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

(a) Mounting - On racks.

(b) Initial measurements - Not applicable.

(c) Conditioning - The 24-hour initial drying period prior to the first cycle may be omitted.

(d) Polarization - Unless otherwise specified (see 3.1 and 6.1.2), polarization is applicable. The polarizing voltage shall be applied during steps 1 to 6 inclusive, between all windings not connected directly to the core or case, and the core or case. The polarizing voltage shall be positive with respect to the core and the case.

(e) Loading voltage - Not applicable.

(f) Final examination - Upon completion of step 6 of the final cycle, transformers or inductors shall be removed from the humidity chamber and shall be conditioned for a maximum of 8 hours at standard inspection conditions (see 4.4). After this conditioning period, dielectric withstanding voltage (at reduced voltage), induced voltage, and insulation resistance shall be measured at any temperature above 20°C and at ambient room humidity, but rejections shall be based on measurements made at $25^{\circ}\,{}^{+10^{\circ}}_{-5^{\circ}}$ C and at a relative humidity not greater than 80 percent.

(g) Visual examination - Transformers and inductors shall be examined for any visible damage including corrosion and obliteration of marking.

4.8.20 Overload (see 3.27). The overload test shall be performed for a period of 48 hours for qualification inspection. When transformers and inductors attain an operating temperature of less than the maximum specified for the class during the temperature-rise test specified in 4.8.11.19, the coolant temperature for the overload test shall be increased to a value that results in an operating temperature equivalent to the maximum specified for the class (see 6.11). The overload shall be applied as specified in 4.8.20.1 and 4.8.20.2, as applicable. At the conclusion of the test, all transformers or inductors shall be examined for leakage or other visible damage. Transformers or inductors shall be allowed to cool for approximately 8 hours at standard test conditions (see 4.4) before any additional tests are performed (see 6.9).

4.8.20.1 Maximum voltage. The rated voltage at the minimum frequency of the specified frequency range shall be applied at the rated duty cycle to the primary winding and with rated load connected to the secondary to set the load impedances. The input voltage shall then be raised to 110 percent of the rated voltage. When applicable, rated dc current shall also be applied during the test.

4.8.20.2 Inductors. Inductors shall have 110 percent of all rated dc currents and ac voltages applied at the rated duty cycle.

4.8.20.3 Saturable core devices. Saturable core devices shall be tested as required by 4.8.20.2 except that the load required shall be adjusted to 110 percent of rated current output.

4.8.21 Flammability (grade 5) (see 3.29). Transformers and inductors shall be tested in accordance with method 111 of MIL-STD-202. The following details and exception shall apply:

(a) Point of impingement of applied flame - One of the lower free corners, so that the flame is just in contact with the transformer or inductor. The free corners of the transformer or inductor are those corners which are the greatest distance from the mounting brackets. However, the flame shall be applied so that it will impinge upon the corner or area containing the encapsulating compount.

(b) Allowable time for burning of visible flame on specimen - 3 minutes maximum.

(c) Examinations during and after test - Transformers and inductors shall be examined for evidence of violent burning which results in an explosive-type fire, dripping of flaming material, and visible burning which continues beyond the allowable duration after removal of the applied flame.

4.8.22 Life (see 3.30) (life expectancy 10,000 hours). Transformers and inductors shall be subjected to 5 life cycles a week for a minimum of 12 weeks (2,016 hours). Four of the cycles shall consist of 20 hours during which time the transformers and inductors shall be operated at maximum operating temperature and duty cycle for the class, with loading equal to or greater than rated ac and dc voltages and currents, and 4 hours at room ambient temperature without excitation. The fifth cycle of the week shall be 68 hours at maximum operating temperature and duty cycle for the class with samples loaded as before and 4 hours without excitation at room ambient temperature. The electrical test circuit shall be devised so that an open circuit (see 3.30) or short circuit (see 3.30) during the 5 life cycles shall be detected and the time of failure recorded. For transformers only, the test may be performed with samples loaded back-to-back provided the above-mentioned loading requirements are met. This test may be performed at any ambient temperature provided that the maximum operating temperature for the class is held within $^{+10^{\circ}}_{-5^{\circ}}$ C and no drafts or varying air velocities are present. At the option of the supplier, the test may be performed at 60 Hz for transformers rated at 50/60 Hz and at 400 Hz for transformers rated at 360/400 Hz provided the primary voltage is increased to at

least 1.1 times the rated voltage and the maximum operating temperature for the class is attained. Upon completion of cycling after a minimum of 12 weeks, transformers and inductors shall be tested for insulation resistance (see 4.8.10), dielectric withstanding voltage (at atmospheric pressure) (see 4.8.8.1) using 65 percent of initial test voltage, induced voltage (see 4.8.9), using a voltage sufficient to cause 1.3 times the rated voltage to appear across any winding and partial discharges (see 4.8.12). The continuous or peak partial discharges shall not exceed two times the magnitude of the continuous and peak partial discharges measured at the start of the test. Samples shall also be examined for evidence of physical and electrical damage (see 6.9).

4.8.23 Fungus (see 3.31) Unless certification is provided, transformers and inductors shall be tested in accordance with method 508 of MIL-STD-810 (see 3.1 and 6.1.2).

5. PREPARATION FOR DELIVERY

5.1 Preservation-packaging. Preservation-packaging shall be level A or C, as specified (see 6.1).

5.1.1 Level A.

5.1.1.1 Cleaning. Transformers and inductors shall be cleaned in accordance with MIL-P-116, process C-1.

5.1.1.2 Drying. Transformers and inductors shall be dried in accordance with MIL-P-116.

5.1.1.3 Preservative application. Preservatives shall not be used.

5.1.1.4 Unit packaging. Transformers and inductors shall be individually packaged in accordance with the unit packaging requirements of table H11 herein and MIL-P-116 insuring compliance with the general requirements paragraph under methods of preservation (unit protection) and the physical protection requirements paragraph therein.

5.1.1.5 Intermediate packaging. Not required.

5.1.2 Level C. Transformers and inductors shall be clean, dry and individually packaged in a manner that will afford adequate protection against corrosion, deterioration and physical damage during shipment from supply source to the first receiving activity.

5.2 Packing. Packing shall be level A, B or C, as specified (see 6.1).

5.2.1 Level A. The packaged transformers and inductors shall be packed in accordance with the level A packing requirements of table H11 Boxes conforming to PPP-B-636 shall have all seams, corners and manufacturer's joint sealed with tape, two inches minimum width, conforming to PPP-T-60, class 1 or PPP-T-76. The closure, waterproofing and banding requirements for the other level A shipping containers shown in table H11 shall be in accordance with the applicable box specification. Banding (reinforcement requirements) for all fiberboard containers (PPP-B-636 and PPP-B-640) shall be applied in accordance with the applicable appendix using non-metallic or tape banding only.

TABLE H-11 Packaging method, unit supplementary and shipping container selection chart.

Unit packaging				Packing		
Net weight of item (pounds)	Grades	Packaging method or submethod of MIL-P-116	Unit or supplementary container	Level A	Level B	Level C
$\leq$2.99		III	PPP-B-566 or PPP-B-676	PPP-B-636, class weather resistant.	PPP-B-636, class domestic.	See 5.2.3
		IA-8 (unless otherwise specified, see 6.1)				
3.00-9.99		III	PPP-B-636, class domestic.	PPP-B-636, class weather resistant.	PPP-B-636, class domestic.	See 5.2.3
		IA-8 (unless otherwise specified, see 6.1)				
10.00-19.99		III	PPP-B-636, class weather resistant.	PPP-B-636, class weather resistant. PPP-B-640, class 2; PPP-B-601, overseas type; or PPP-B-621, class 2.	PPP-B-636, class domestic; PPP-B-640, class 1; PPP-B-601, domestic type or PPP-B-621, class 1.	See 5.2.3
		IA-14 (unless otherwise specified, see 6.1)	Inner container: PPP-B-636, class domestic. Outer container: PPP-B-636, class weather resistant.			
20.00-69.99		III	Unit container shall conform to the designated level of packing and shall serve as the shipping container.			See 5.2.3
		IA-14 (unless otherwise specified, see 6.1)	Inner container: PPP-B-636, class domestic. Outer container shall conform to the designated level of packing and shall serve as the shipping container.			
$\geq$70.00		III	Unit container shall conform to the designated level of packing and shall serve as the shipping container.	PPP-B-601, overseas type or PPP-B-621, class 2. When the weight exceeds 200 pounds, skids shall be applied in accordance with the applicable specification.	PPP-B-601, domestic type or PPP-B-621, class 1. When the weight exceeds 200 pounds, skids shall be applied in accordance with the applicable specification.	See 5.2.3

5.2.2 Level B. The packaged transformers and inductors shall be packed as specified in 5.2.1 except that the containers shall conform to the level B packing requirements of table H11. Box closure shall be in accordance with the applicable box specification.

5.2.3 Level C. The packaged transformers and inductors shall be packed in shipping containers in a manner that will afford adequate protection against damage during direct shipment from the supply source to the first receiving activity. These packs shall conform to the applicable carrier rules and regulations.

5.2.4 Unitized loads. Unitized loads, commensurate with the level of packing specified in the contract or order, shall be used whenever total quantities for shipment to one destination equal 40 cubic feet or more. Quantities less than 40 cubic feet need not be unitized. Unitized loads shall be uniform in size and quantities to the greatest extent practicable.

5.2.4.1 Level A. Transformers and inductors, packed as specified in 5.2.1, shall be unitized on pallets in conformance with MIL-STD-147, load type I, with a fiberboard cap (storage aid 4) positioned over the load.

5.2.4.2 Level B. Transformers and inductors, packed as specified in 5.2.2, shall be unitized as specified in 5.2.4.1 except that the fiberboards caps shall be class domestic.

5.2.4.3 Level C. Transformers and inductors, packed as specified in 5.2.3, shall be unitized with pallets and caps of the type, size and kind commonly used for the purpose and shall conform to the applicable carrier rules and regulations.

5.3 Marking. In addition to any special marking required by the contract or order (see 6.1), each unit package, supplementary and exterior container and unitized load shall be marked in accordance with MIL-STD-129.

5.4 General.

5.4.1 Exterior containers. Exterior containers (see 5.2.1, 5.2.2 and 5.2.3) shall be of a minimum tare and cube consistent with the protection required and shall contain equal quantities of identical stock numbered items to the greatest extent practicable.

5.4.2 U.S. Air Force requirements. For U.S. Air Force requirements submethods IC3 and IC-2 with supplementary container conforming to PPP-B-636, class weather resistant, special requirements shall be used in lieu of submethods IA-8 and IA-14, respectively (see table H-11).

6. NOTES

6.1 Ordering data.

6.1.1 For transformers and inductors covered by coordinated specification sheets. Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Title, number and date of the applicable specification sheet, and the complete military part number (see 1.2.1 and 3.1).
(c) Whether hardware is required for screw terminals (see 3.5.2.6).
(d) Levels of preservation-packaging and packing required (see 5.1 and 5.2). Method of preservation, if other than submethods IA-8 and IA-14 (see table H-11).
(e) Special marking, if required (see 5.3).

6.1.2 For transformers and inductors not covered by specification sheets: Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Type designation (minus the identification number) covering the grade, class, family and envelope and mounting dimensions (see 1.2 to 1.2.1.5, inclusive).
(c) Applicable drawings covering envelope, mounting and other physical dimensions (see 1.2.1.5).
(d) When first article inspection is performed (see 3.3), the following is required:
   (1) The laboratory at which first article inspection is to be performed.
   (2) Sample, submission of data, and inspection routine, if other than that specified (see 3.3 and 6.3).
(e) Type of terminal (see 3.5.2). Whether hardware is required for screw terminals and detail requirements of screw terminals (see 3.5.2.6).
(f) Whether the core is to be grounded to the case or accessible electrically (see 3.5.5).
(g) Whether a paint finish is required and if it is to be applied to mounting surface (see 3.5.6).
(h) Electrical characteristics and tolerances (see 3.15).

(i) Whether the partial discharge test is required (see 3.17), and if so:

  (1) The acceptable level of corona (see 3.17).
  (2) Required test circuit of figure H7 (see 4.8.12.1, 4.8.12.2, and figure H7).

(j) Maximum ambient temperature and maximum allowable temperature rise (see 1.2.1.3, 3.16 and 4.8.11.19).

(k) Marking (see 3.32).

  (1) Additional information for marking of individual families (see 3.32.1 to 3.32.3, inclusive).
  (2) Terminal identification if other than by numbering (see 3.32.4).

(l) Rated voltages, loads and tolerances (see 4.4.2).

(m) Applicable electrical characteristics (see 4.8.11 to 4.8.11.19, inclusive).

(n) Whether alternate seal test is required (see 4.8.7.).

(o) Dielectric-withstanding test voltages for the following:

  (1) Windings with special dielectric features (see 4.8.8.1.1).
  (2) Pulse transformers (see 4.8.8.1.1).

(p) Whether dielectric-withstanding-voltage test at reduced barometric pressure is applicable and test condition (see 4.8.8.2).

(q) Induced voltage:

  Frequency range for all transformers and inductors except saturating core power (see 4.8.9.1).

(r) Fungus (see 4.8.23).

(s) Temperature rise (see 4.8.11.19).

(t) Vibration test (see 4.8.15).

  (1) Whether 4.8.15.1 or 4.8.15.2 is applicable.
  (2) If 4.8.15.2 is applicable, the test condition shall be specified if other than D.
  (3) During vibration test, whether transformers and inductors are to be preheated in a test chamber to the specified maximum ambient temperature for the class plus one-half the allowable temperature rise (see 4.8.15.1).

(u) Shock test (see 4.8.16).

(1) The test condition shall be specified if other than I.

(2) Whether high-impact is applicable (see 4.8.16.2).

(v) Whether polarization is not applicable during moisture resistance test (see 4.8.19).

(w) Levels of preservation-packaging and packing required (see 5.1 and 5.2). Method of preservation, if other than submethod IA-8 and IA-14 (see table H11).

(x) Special marking if required.

(y) Whether salt spray test is required (see 3.18).

6.2 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), Dayton, Ohio 45444 (see 3.2).

6.3 First article inspection. Information pertaining to first article inspection of products covered by this specification should be obtained from the procuring activity for the specific contracts involved (see 3.3).

6.4 Assignment of type designation. Complete type designations, including the identification number (see 1.2.1.6), will be assigned by the cognizant government procurement agency, upon request of the Army, the Navy, or the Air Force, only when a coordinated specification sheet has been established (see 4.5.1).

6.5 Envelope and mounting dimensions. Equipment designers should give first consideration to using standard case configurations.

6.6 Dielectric withstanding voltage. Users of transformers and inductors should note that the units have been previously tested at 100 percent dielectric withstanding voltages at least one or more times and, therefore, should be tested only at 75 percent test voltage during subsequent inspections such as during incoming inspection by a purchaser. For units with a working voltage in excess of 10 kV, partial discharge measurements at rated voltage should be considered in addition to dielectric withstanding voltage.

6.7 Induced voltage test for inductors. For inductors, the test voltage is applied directly across the coil.

6.8 Magnetic shielding. The approximate magnetic field strength for the Helmholtz structure described in 4.8.11.8 and illustrated on Figure H8 is 43.6 oersteds per peak ampere.

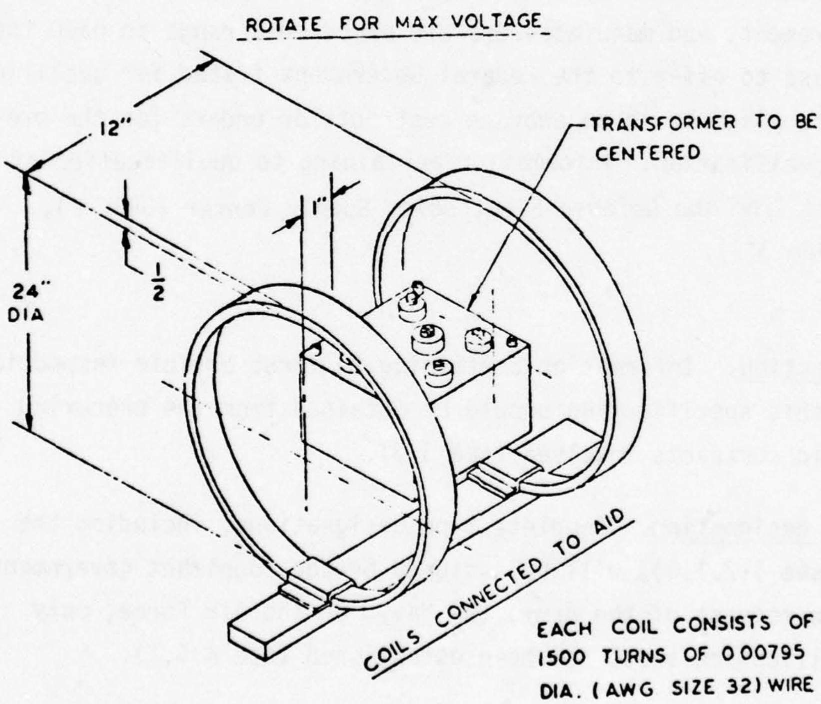


FIGURE H8. Helmholtz structure for magnetic shielding.

6.9 Overload and life tests (method of mounting). The same method of mounting may be used for the overload and life tests.

6.10 Notes for airborne application.

6.10.1 Laminated phenolics. It is recommended that laminated phenolics not be used in locations where they would be exposed to heavy electric discharges during normal operations or under faulty conditions, because of the flammable conditions that might occur.

6.10.2 Transformer and inductor sizes. Manufacturers should strive to provide the smallest and lightest transformers and inductors.

6.11 Ambient temperature increase. Ambient temperature increase for use under 4.8.20 will be derived on an assumed linear extrapolation. For example, a class R unit operated under 4.8.11.19 at an ambient temperature of $70^{o}C$ with a $20^{o}C$ temperature rise would be operated under 4.8.20 at an ambient temperature of $85^{o}C$ ($105^{o}C - 20^{o}C = 85^{o}C$). The normal cooling systems shall be active during the tests.

6.12 Test circuits for electrical characteristics. The actual circuit may be used for group B electrical inspection testing in lieu of the test circuits specified herein (see 4.8.11).

6.13 Reduction of dielectric-withstanding-voltage testing. When the dielectric-withstanding-voltage potential required between windings is greater than that required between windings and ground, and where there is sufficient insulation used in the construction of the transformer or inductor, a reduction of testing may be accomplished by specifying a sufficiently high winding-to-ground potential so that it includes the required test potential between windings.

6.14 Notes regarding general applications for equipment designers. The equipment designer, by proper application of the information contained in the following paragraphs, can communicate to the transformer or inductor designer of the supplier a more complete understanding of his requirements and thus realize better equipment reliability. This will also prevent the costly over-specification of requirements not needed for the intended use.

6.14.1 Specification sheet transformers and inductors. For any transformer or inductor requirement, the specification sheets listed in supplement 1 should first be reviewed and if usable for the requirement, should be specified.

6.14.2 Temperature. The class designation in table H-2 refers solely to maximum operating temperature and has no relation to types of insulation material. Any insulation material may be used in any class of transformer or inductor, depending entirely upon the maximum operating temperature and its associated life expectancy. The maximum operating temperature refers to the maximum ambient temperature specified for equipment operation plus the internal temperature rise at the time that thermal stability is reached. It should be noted that where the total of the specified maximum ambient temperature and the specified allowable temperature rise exceeds, by any amount, the maximum operating temperature for any given class, the unit must be described by the letter designating the next higher class designation and meet the requirements thereof.

6.14.2.1 Maximum operating temperature. The maximum operating temperature is the same as the allowable temperature rise plus the maximum ambient temperature for the class. Accordingly, temperature rise is the allowable temperature differential between the ambient and maximum operating temperature for a given insulation for a specified life. For example, class R has a maximum operating temperature designation of 105°C; this is normally a 65° C ambient plus a 40°C rise. If the temperature rise was determined to be 30°C, this same transformer could operate in an ambient as high as 75°C (75°C + 30°C = 105°C). The transformer cooling system shall be active.

6.14.2.2 Temperature rise. Temperature rise is normally measured and rated at sea level. At higher altitudes, the temperature rise will increase and should be compensated for in the equipment design with cooling system considered.

6.14.2.3 Ambient temperature. It is not recommended that a higher operating ambient temperature be specified than that to which the transformer or inductor will actually be exposed. To do so will result in a larger and heavier unit than is needed. In the absence of a specified ambient temperature in the individual document, the following ambient temperatures may be used for the temperature rise test; class Q (65°C), class R (65°C), and class S (85°C).

6.14.3 Envelope and mounting dimensions. Equipment designers should give first consideration to using the various standard case sizes (or envelope and mounting dimensions). The use of standard cases results in lower costs and faster delivery, since these cases are generally immediately available from case suppliers' stock and are based on the use of standard laminations.
However, when size is important, it is often necessary to utilize special cores, core materials, and improved types of insulation, with resultant higher costs and delayed deliveries.

6.14.3.1 Overspecified characteristics which affect case size. The unrealistic over specification of certain characteristics can result in a much larger transformer than should be required. For this reason, do not specify:

(a) Greater than actual power requirement.
(b) Lower frequency than actual requirement.
(c) Lower dc resistance than actual requirement.
(d) Higher dc current than actual requirement.
(e) Higher than actual ambient temperature or higher temperature class.
(f) Higher than actual working voltage (including voltage peaks).
(g) Better regulation (lower percent) than actual requirement.
(h) Excessive life expectancy.

6.14.4 Working voltage. The working voltage marked on the transformer or inductor represents the maximum voltage stress that may appear, under normal rated operation, across the insulation being considered. This voltage is based on the circuitry with which the unit is associated. The working voltage marking enables personnel testing the units to determine the correct dielectric withstanding test voltages to be applied.

CAUTION: DO NOT USE TEST VOLTAGES AS THE OPERATING WORKING VOLTAGES OF THE TRANSFORMER OR INDUCTOR.

6.14.5 Overload. Transformers and inductors designed in accordance with this specification are capable of withstanding an overload of 10 percent for the transformer duty cycle.

6.14.6 Altitude rating. The altitude rating marked on the transformer or inductor indicates that the associated working voltages are based on a pressure equivalent to this altitude. However, the units can still be operated at higher altitudes if the working voltages are properly derated.

6.14.7 Marking. Detailed marking requirements are indicated in 3.32.1 to 3.32.4 inclusive. Where conditions are such that less information is required or desired, such information must be clearly specified in the procurement document.

6.14.8 Environmental characteristics. Care should be exercised in specifying environmental test requirements to insure that the unit should be tested in a manner compatible with the environment actually present. Thus, for example, if the end equipment is to be shock mounted, sealed, or will include cooling facilities, the transformer or inductor may encounter a less stringent environment. However, it should be noted that the effect on a transformer or inductor of the conditions to

which an equipment is subjected, because of position or method of mounting, may be entirely differerent from the effect on the end equipment as a whole.

6.14.9 Electrical characteristics. Only those characteristics and tolerances which are pertinent to the particular design should be specified. Normally pertinent characteristics, arranged by groups of applications, are indicated in the following paragraphs: (All the listed characteristics may not be applicable to each design; also, the listed characteristics do not embrace all of the characteristics which may be applicable).

6.14.9.1 General. Where possible, the associated circuitry should be shown for reference, indicating tube types, and other important component parts, in order to aid in obtaining optimum design.

6.14.9.2 Power transformers.

(a) Nominal primary voltage and possible variation. (Taps on winding are to be clearly defined.)
(b) Operating frequency range.
(c) Secondary rms load voltages with allowable tolerance at nominal input voltage and rated loads.
(d) Secondary rated rms and dc load currents and possible variations.
(e) Allowable regulation - The basis for regulation should be clearly stated, e.g., 5 percent to 100 percent load, over temperature range, etc.
(f) Electrostatic shielding in accordance with 4.8.11.8, including the minimum ratio of attenuation.
(g) Polarity of windings.
(h) Surge conditions and transient peaks.
(i) Corona limits should never be specified unless absolutely necessary.
(j) Capacitive or inductive input should be specified if used in a rectifier or filter circuit.
(k) Efficiency at full load.

6.14.9.3 Inductors.

(a) Rated inductance and required limits at nominal rms voltage and frequency, and dc current.
(b) Allowable dc resistance.
(c) Storage factor (Q) at the specified voltage and frequency.

6.14.9.4 Saturating core power transformers.

(a) Test circuit for intended use
(b) Drive transistors
(c) DC source voltage and range of variation
(d) Output load currents
(e) Design frequency
(f) Allowable regulation - the basis for regulation should be clearly stated, e.g., 5 to 100 percent load over temperature range, etc.
(g) Polarity of windings
(h) Filter input circuit if used in rectifier application
(i) Rise and fall times, maximum overshoot, etc., if applicable

6.14.10 Resistance to solvents. If resistance to solvents test is not performed, the manufacturer shall certify that the intended use of the transformer or inductor is not for printed circuit application.

6.14.11 Seal. Where doubt exists to the adequacy of the seal, due to emission of bubbles, an insulation resistance across the seal shall be performed and if less than 10,000 megohms, additional tests shall be performed.

6.15 Center-tapped secondary. A center-tapped secondary is described by the winding end-to-end voltage with a tap at the mid-point.

6.15.1 Center-tapped secondary supplying unrectified loads. The current refers to the rms current flowing from end-to-end of the winding. Unless otherwise specified, the center-tap lead does not carry the load current (see figure H9)

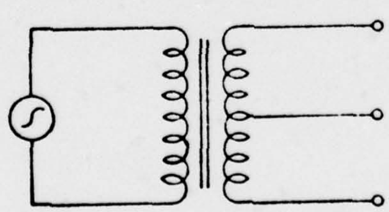


FIGURE H9 Center-tapped secondary supplying unrectified loads.

6.15.2 Center-tapped secondary supplying rectified loads. The winding current is the rms equivalent of the dc load current. The rms current is dependent upon the type of filter used with the rectifier. The type of filter and the dc load current must be specified. (EXAMPLE: Capacitive input filter, 100 mA dc load.) Unless otherwise specified, the center-tap lead carries the full dc load current (see figure H10).

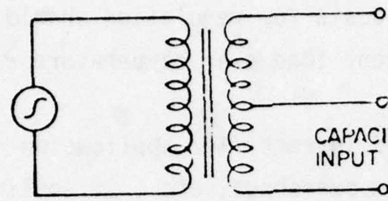


FIGURE H10 Center-tapped secondary supplying rectified loads.

6.16 Dielectric withstanding voltage (at atmospheric pressure)(points of application of test voltage, winding to case or core). Grade 8 units (when applicable) shall be wrapped lightly with metal foil on as many surfaces as practicable in lieu of a metal case.

6.17 International standardization agreement. Certain provisions of this specification are the subject of international standardization agreement (NEPR No. 20). When amendment, revision, or cancellation of this specification is proposed which will affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

SUBMISSION FOR QUALIFICATION INSPECTION

10. SCOPE

10.1 This paragraph details the procedures for submission of samples, with required data, for qualification testing and approval of transformers and inductors covered by this specification.

20. SUBMISSION

20.1 Qualification of transformers and inductors based on complete testing (part I of QPL-27).

20.1.1 Identification data required.

(a) Type designation of the transformer or inductor described on a specification sheet. (Transformers or inductors covered by existing specification sheets.)

(b) For transformers or inductors that are comparable with an item covered by an existing specification sheet and the requirements of which can be added to the sheet, the information of Figure H11 shall be submitted. For transformers or inductors that cannot be added to an existing specification sheet, a complete specification sheet shall be submitted, encompassing the information required by Figure H11 The specification sheet shall be in the format of existing specification sheets and shall be suitable for reproduction by the photo-offset method.

20.1.2 Sample. A sample consisting of one transformer or inductor for which qualification is sought shall be subjected to the tests of Table H5

20.2 Qualification of transformers and inductors based on similarity (Part II of QPL-). Only transformers or inductors which have passed the complete tests of Table H5 shall be used as basis for comparison for qualification based on similarity.

20.2.1 Similar transformers or inductors. A similar transformer or inductor is defined as a transformer or inductor which when compared to a specific qualified transformer or inductor meets the following criteria:

(a) Same or lower class.

(b) Same type of external and internal mountings; similar shape; same type of case construction; nominal wall thickness within 25 percent when a case is used.

(c) Linear envelope dimensions not greater than 150 percent nor less than 70 percent of the corresponding dimensions; total volume of envelope not greater than 250 percent.

(d) To be used at same or lower operating voltages, and same or lower dielectric stress per mil of same insulation.

(e) Same or greater wire size (cross sectional area) and same wire coating material for corresponding windings.

1/ (f) Same processing material for case, finish, marking.

(g) Same processing material for potting, insulation, impregnating and filling.

(h) Same grade.

(i) To be used at same or lower altitudes.

(j) Same terminal construction and material including insulating and gasketing parts; same or lower terminal strength requirements for same size terminals.

(k) Same shock and vibration requirements.

1/ This criteria may be compared to any qualified transformer or inductor on Part I of QPL-27.

20.2.2 Identification data required. The data required shall be in accordance with 20.1.1(b) and that required by Figure H12 shall also be submitted.

20.2.3 Sample. All units of each type for which qualification is sought shall be subjected to the inspection specified in Table H6.

Identification data (to be completed by manufacturer):

1. Name of Manufacturer:
2. Address of Manufacturer:
3. Manufacturer's part number:
4. Federal supply code assigned to Manufacturer:
5. Date of entries completed:

Instructions for use of this form:

Enter all information, including numerical values as required by this form, using as your guide applicable military specification or standard scope, requirement, and methods of examination and test paragraphs. Military specification sheets, if any, to which the transformer or inductor can be added:

MIL-_-____________________. (enter slash number)

____ This item cannot be added to any existing specification sheet

Type designation-(see MIL-_-__, 1.2.1 thru 1.2.1.6) TF____________
enter symbols.

Federal Stock Number (FSN) (check applicable block):

___ Existing FSN assigned to this transformer or inductor is ____-____-______.
(enter numerals)

___ No FSN is presently assigned to this transformer or inductor.

Application of transformer or inductor:

1. Military equipment identification (Joint Electronics Type Designation System): ____________________
(enter identification no.)

2. Military documents (check all applicable blocks and enter information requested):

_____ Technical Order (T.O.) ____________________.
(identification no.)

____ Technical Manual (T.M.)____________________.
(identification no.)

____ Military drawing__________________.
(identification no.)

FIGURE H-11 Transformer or inductor data sheet

In the space below, provide outline drawings in as many views as are required to show all of the principal exterior features of this transformer or inductor including case, mounting and terminal dimensions 1/ and tolerances 2/, and terminal identification.

1/ Dimensions shall be given in decimal fractions, accurate to three decimal places.

2/ State dimensions as nominal value, with tolerances:

Examples: $1.750 \pm\begin{matrix}0.000\\0.125'\end{matrix}$ 2.50 ± 0.016.

REQUIREMENTS:

Case.

Material (check applicable block): ____ Metal

____ Other.____________________ (specify material)

Nominal weight:____________________ (enter value) grams, pounds. (cross out one)

Terminals.

Material:______________________________ (specify)

Type (check applicable block):

____ Solder Terminal.

____ Screw Thread

____ Solid wire lead other than printed circuit.

____ Insulated wire leads.

____ Pin for printed circuits.

____ Pin for electron tube sockets

____ Special:____________________ (specify type)

Solderability (see 4.8.2).

Check applicable block:

____ 4.8.2.1 ____ 4.8.2.2

Resistance to solvents (see 4.8.3). method 215, MIL-STD-202.

Check applicable block:

____ Applicable ____ Not Applicable

Thermal shock (see 4.8.4).

Check applicable block:

____ 10 cycles

____ 25 cycles

____ other, specify number of cycles__________.

Resistance to soldering heat (see 4.8.5).

Bath (4.8.5.1) Iron (4.8.5.2)

_____ _____

Terminal strength (see 4.8.3), method 211, MIL-STD-202.

Check applicable blocks:

Equivalent diameter at cross section as defined in Table X

______________ inches.
enter value)

____ Condition A (pull), applied force (in accordance with Table IX):

____ 2.0 pounds ____ _____ pounds

____ Condition B (bend

____ Condition D (twist)

____ Condition E (torque)

____ Screw-thread terminals:

Torque: ______________pound-inches
(enter value)

FIGURE H11 Transformer or inductor data sheet - Continued

____ Other non-wire, rigid type terminals, if equivalent diameter is greater than 1/2 inch:

Torque: ____________ ounce-inches:
(enter value)

Seal (see 4.8.7)

Check applicable block:

Liquid	Gas	Other
____ 4.8.7.1	____ 4.8.7.2	____ 4.8.7.3

Dielectric withstanding voltage test.

Check applicable blocks:

____ At atmospheric pressure (see 4.8.8.1), method 301, MIL-STD-202:

Magnitude of test voltage:______________ volts, rms.
Terminal identification for applicable test voltage,__________.

____ At barometric pressure (see 4.8.8.2). In accordance with 4.8.8.1 and method 105, MIL-STD-202, test condition.

____
(specify condition letter).

Magnitude of test voltage:______________ volts, rms.
(enter value)

Induced voltage (see 4.8.9).

Check applicable block:

____ 4.8.9.1 ____ 4.8.9.2

Insulation resistance (see 4.8.10), method 302, MIL-STD-202, test condition B.

Dc test potential: ____________ volts.
(enter value)

FIGURE H11 Transformer or inductor data sheet - Continued

Electrical characteristics and tolerances (see 4.8.11 to 4.8.11.19).

No Load ______

Rated Load ______

Dc resistance and resistive unbalance ______

Inductance and inductive unbalance ______

Harmonic distortion ______

Primary impedance ______

Temperature rise ______

Efficiency ______

Regulation ______

Core loss ______

Self-resonant frequency ______

Insulation Power Loss ______

Electrostatic shielding ______

Magnetic shielding ______

Center-tap balance at low levels ______

Polarity ______

Storage factor ______

Wave shape ______

Turns ratio or voltage ratio ______

Bushings ______

Short Circuit Test ______

Impulse ______

Partial discharge: ______

Dielectric Withstanding Voltage ______

Frequency ______

Working Voltage ______

FIGURE H11 Transformer or inductor data sheet - Continued

Power level____________________________________

Primary winding:

Voltage____________________________________

Current____________________________________

VA____

Impedance__________________________________

Secondary winding(s):

Number_____________________________________

Voltage, each______________________________

Current, each______________________________

Pulse electrical characteristics____________________

____

Other electrical characteristics______________________

____

<u>Temperature rise (see 4.8.11.19)</u>

Specify values:

____ Not applicable (when the transformer is rated at 0.8 watt average output or less, and for inductors where the product of the d-c resistance and the square of the rated current is 0.2 watt or less.

		I	II	III
	Methods			
Temperature rise: ________	degrees C	____	____	____

Ambient temperature ________ degrees C

Maximum operating temperature __________degrees C

<u>Partial discharges (see MIL-T-27, 4.8.12</u>

Check applicable block:

Required test circuit of figure 10

________ 1 ________ 2 ________ 3

<u>Salt spray (see 4.8.14).</u>

Check block if salt spray is applicable ________

FIGURE H11 Transformer or inductor data sheet - Continued.

Vibration (see 4.8.15).

Check applicable block:

____ Low frequency (see 4.8.15.1), method 201, MIL-STD-202.

____ High frequency (4.8.15.2), method 204, MIL-STD-202.

Shock (see 4.8.16).

Check applicable block:

____ Specified pulse (see 4.8.16.1), method 213, MIL-STD-202,

test condition: I ______ or specify condition letter ______

____ High impact (see 4.8.16.2), method 207, MIL-STD-202

Moisture resistance (see 4.8.19), method 106, MIL-STD-202

Check applicable block:
Polarizing voltage:

____ Applicable ____ Not applicable

Overload (see 4.8.20)

Check applicable block:

____ Applicable ____ Not applicable

Flammability (see 4.8.21), method 111, MIL-STD-202.

Check applicable block:

____ Applicable ____ Not applicable

Life (see 4.8.22).

Check applicable block:

____ Loaded ____ Not loaded

Fungus (see 4.8.23), method 508, MIL-STD-810

Check applicable block:

____ Applicable. ____ Certification

FIGURE H11 Transformer or inductor data sheet - Continued

DATA SHEET FOR
POWER TRANSFORMER

ELECTRICAL RATING

Primary (1-2): ________VA, ________Vrms, ________Hz
Secondary (3-4): ________Vrms, ________Arms
(5-6) ________Vrms, ________Arms
(etc)
Duty cycle:

Working voltage: (Primary) (Secondary)
Altitude:
Operating temperature range:

PHYSICAL CHARACTERISTICS

Case size:
Weight: (In grams, oz(s) or pound(s))
Terminal type:
Terminal height:

ELECTRICAL PROPERTIES

Dielectric withstanding voltage (each winding):
At sea level - ________volts rms
At reduced barometric pressure - ________volts rms
No load (see 4.8.11.1): With (primary voltage) volts and (frequency)Hz in (1-2):
Current in (1-2): ________ma max
Power in (1-2): ________watts max
Voltage across (3-4): ________volts ± __%
Voltage across (5-6): ________volts ± __%
Voltage across (etc): ________volts ± __%
Rated load (see 4.8.11.2): With primary volts & Hz across (1-2):
Voltage across (3-4): ________volts ± __%
Voltage across (5-6): ________volts ± __%
Voltage across (etc): ________volts ± __%
Electrostatic shielding: Voltage ratio: __ to __ at ________kHz.
DC resistance: (1-2)
(3-4)
(5-6)
Polarity: Additive, with terminals __ and __ connected.
Temperature rise: ____°C with ________volts rms, ________Hz
across (1-2) at an ambient temperature of ____°C.

(In the space below, provide circuit diagram)

DATA SHEET FOR
POWER INDUCTOR

ELECTRICAL RATING

Inductance: ________h min
Current: ________amp. dc
Voltage: ________volts rms
Frequency: ________Hz
DC resistance: ________ohms max.
Duty cycle: ________
Working voltage: ________volts max.
Altitude: ________feet max.
Operating temperature: ________°C, max.

PHYSICAL CHARACTERISTICS

Case size: ________
Weight: ________pounds max.
Terminal type: ________
Terminal height: ________in. max.

ELECTRICAL TEST PROPERTIES

Dielectric withstanding voltage:
At sea level - ________volts rms
At reduced barometric pressure - ________volts rms
Inductance: With ____volts rms, ____Hz, and ________amp dc applied to (1-2): ________henries min.
DC resistance: (1-2) ________ohms max.
Temperature rise: ____°C with ________volts rms, ________Hz, ________amp dc applied to (1-2) at an ambient temperature of ____°C max.

(In the space below, provide circuit diagram)

Characteristics	Characteristics of transformers and inductors being submitted for qualification based on similarity	Characteristics of transformers and inductors having qualification
Identification data	Name of manufacturer: Address of manufacturer: Manufacturer's part number Code assigned to manufacturer:	Name of manufacturer: Address of manufacturer Manufacturer's part number Test or qualification reference: Code assigned to manufacturer:
Operating temperature	85° C ____ 155°C____ 105° C____ 170°C____ 130° C____ >170°C____	85°C____ 155°C____ 105°C____ 170°C____ 130°C____ >170°C____
Ambient temperature (operating temperature-temperature rise)		
External mounting Internal mounting Nominal wall thickness Envelope dimensions Case volume Grade	Grade 7 ____ Grade 9 ____ Grade 8 ____ Grade 10____	Grade 7 ____ Grade 9____ Grade 8 ____ Grade 10____
Wire size Coating material		
Case material	Metal ____ Other (specify)____	Metal ____ Other (specify)____
Case finish	Light gray, semigloss____	Light gray, semigloss____
Operating voltage		
Potting Insulation Impregnation Filling		
Altitude	10,000 ft. ____ 50,000 ft. ____	10,000 ft. ____ 50,000 ft. ____
Terminal construction, material and finish (including insulating and gasketing parts)		

FIGURE H12 Transformer and inductor similarity comparison sheet.

APPENDIX I

INTERIM REPORT DISTRIBUTION LIST

An interim report containing the criteria documents reproduced as appendices A through F and H were issued to the following industrial and government agencies and personnel for comment and critique. Comments and critiques were evaluated and included in this final report.

1. ASD/ENACD
   Attn: Mr. D. R. Gordon
   Wright-Patterson AFB, OH 45433

2. Mr. James P. O'Loughlin
   AFWL/ALE
   Kirtland AFB, NM 87117

3. Dr. L. I. Amstutz
   U. S. Army MERADCOM
   DRDME-EA
   Ft. Belvoir, VA 22060

4. ASD/XR
   Attn: Mr. Herb Hutchinson
   Wright-Patterson AFB, OH 45433

5. AFAPL/POD-1
   Attn: Capt. H. L. Southall
   Wright-Patterson AFB, OH 45433

6. Mr. Bruce B. Gamble
   General Electric Co.
   Corporate R&D Center
   Bldg. 37 Rm 373
   P.O. Box 43
   Schenectady, NY 12301

7. Mr. D. L. Mang
   Rowe Industries, Inc.
   6225 Benore Rd.
   Toledo, OH 43612

8 Mr. L. E. Wilson
   Friendship International Airport
   P.O. Box 746
   Baltimore, MD 21203

9. Mr. J. A. Goldlust
   Dielectric Sciences
   5 South Avenue
   Burlington, MA 01803

10. Mr. C. B. Kegerise
    AMP Capitron Division
    Washington Square Apts.
    2690-C Old Forge Rd.
    Columbus, OH 43209

11. Dr. J. H. Parker, Jr.
    Westinghouse Electric Corp.
    Research and Development Center
    1310 Beulah Rd.
    Pittsburgh, PA 15235

12. Mr. J. L. McCabria
    Westinghouse Electric Corp.
    Aerospace Electrical Div.
    P.O. Box 989
    Lima, OH 45802

13. Mr. James P. Welsh
    Thermal Technology Laboratory, Inc.
    422 Niagara Falls Blvd.
    Buffalo, NY 14223

14. Mr. F. B. McCarty
    Airesearch Manufacturing Co. of California
    2525 West 190th St.
    Torrance, CA 90509

15 Mr. Mario Gigante
   National Electric Coil
   800 King Ave
   Columbus, OH 43216

16. Dr. R. D. Parker
Bldg. 6, M/S D113
Culver City, CA 90230

17. Dr. Charles Huddleston
Naval Surface Weapons Center
White Oak, MD 20910

18. Dr. Frank Rose
Naval Surface Weapons Center,
Code F10
Dahlgren, VA 22448

19. Tobe Deutschmann Labs, Inc.
550 Turnpike St.
Canton, MA 02021

20. Maxwell Laboratories, Inc.
Attn: Dr. Alan Kolb
9244 Balboa Ave.
San Diego, CA 92122

21. ASD/ENJE
Attn: Mr. Jim Barrett
Wright-Patterson AFB, OH 45433

22. U. S. Naval Ordnance Laboratory
Attn: Mr. E. L. Harris, Code 313
Silver Spring, MD 20910

23. Naval Research Laboratory
Office of Naval Research
Attn: Dr. F. Quelle
475 Summer St.
Boston, MA 02210

24. Capacitor Specialists, Inc.
P. O. Box 2052
Escondido, CA 92025

25. Dr. T. R. Burkes
Texas Tech University
Department of Electrical Engineering.
Lubbock, TX 79401

26. ASD/ENAMA
Attn: Mr. Vic Moratz
Wright-Patterson AFB,OH 45433

27. AirResearch Manufacturing
Company of California
Attn: Mr. Leon Schipper
2525 West 190th St.
Torrance, CA 90278

28. Los Alamos Scientific Laboratories
Attn: Dr. J. D. Rogers
P. O. Box 1663
Los Alamos,NM 87544

29. Physics International Company
Attn: Mr. Jan D. Smith
2700 Merced St.
San Leandro, CA 94577

30. Sangamo Electric Company
P.O. Box 359
Springfield, IL 62705

31. Sprague Electric Company
125 Marshall St.
North Adams, MA 01247

32. TRW, Inc.
Systems Group
One Space Park
Redondo Beach, CA 90278

33. Mr. Robert Gray
Rome Air Development Center
Air Force Systems Command
Griffin AFB, NY 13441

34. Hughes Aircraft Company
Electromagnetic Engineering Section
Components and Materials
Laboratories
Attn: Mr. J. K. Kisch
Culver City, CA 90230

35. AFWL/LEAPS
Kirtland AFB, NM 87117

36. U.S. Army Electronics Command
Electronics Technology and
Devices Laboratory
BPDTA/Mr. S. Schneider
Fort Monmouth, NJ 07703

37. U.S. Army Missile Command
AMSMI-RRL
Attn: Mr. W. McKnight
Redstone Arsenal, AL 35809

38. Magnetic Corporation of America
67 Rogers St.
Cambridge, MA 02142

39. University of Buffalo
Department of Electrical Engineering
Attn: Dr. A.S. Gilmour, Jr.
3435 Main St.
Buffalo, NY 14214

40. Douglas Aircraft Company
Attn: Mr. W. B. Yopp
3855 Lakewood Blvd.
Long Beach, CA 90801

41. Gould Inc., Power Systems Division
Apparatus Research Dept.
Attn: Dr. Rolf Dethlefsen
P. O. Box 98
Greensburg, PA 15601

42. Rocketdyne Division
Rockwell International
Attn: Mr. R. Siegler
6633 Canoga Avenue
Canoga Park, CA 91304

43. Naval Air Development Center
Attn: Mr. Howard Vreland
Warminster, PA 18974

44. Boeing Aerospace Company
Attn: Mr. Ken Kennerud
P. O. Box 3999
M.S. 13-85
Seattle, WA 98124

45. Dr. Francis Schwartz
Power Electronics Associates,Inc.
Round Hill Rd.
Lincoln, MA 01773

46. McDonnell Douglas
AHL, Jeffrey L.
St. Louis, MO 63042

46. AVCO Everett Research Lab
Dr. J. Daugherty
2385 Revere Beach Parkway
Everett, MA 02149

47. Math Sciences Northwest
Attn: Dr. R. E. Center
Bellevue, WA 98009

48. Sandia Laboratories
Attn: Mr. J. B. Gerardo
Albuquerque, NM 87117

49. Stanford Research Institute
Attn: Mr. R. M. Hill
Menlo Park, CA 94025

50. Northrop Research and Technology Center
Attn: Mr. M. M. Mann
3401 W. Broadway
Hawthorne, CA 90250

51. Axel Electronic, Inc.
Attn: Mr. Stanley Zweig
134-20 Jamaica Ave.
Jamaica, NY 11418

☆U.S.Government Printing Office: 1979 — 657-002/530